

Ph.D Thesis.

"Agricultural Geography
OF
The United Provinces."

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INTRODUCTION

CHAPTER I.

An attempt has been made in the following pages to present a survey of the agricultural conditions and practices in the United Provinces of Agra and Oudh as controlled by the geographical factors. The provinces cover an area of 112,191 square miles including the Native States of Tehri, Rampur and Benares and has a population of 49,614,833. The corresponding figures for the British Isles reveal that the two countries are ideal for comparison regarding the size and population. The size of U. P. is a bit smaller and the population a shade larger. The general density of population therefore is higher than that of the British Isles, but the distribution of population in the two countries could not be more dissimilar. The U. P. has 11.2 per cent of urban and 88.8 per cent of rural population whereas the figures are practically reversed in the case of the British Isles, being 80 per cent urban and 20 per cent rural population. This shows that the country under the present inquiry is predominantly agricultural as opposed to industrial British Isles.

The country chosen for the present inquiry is and has been the most interesting part of northern India (1). This has been the cradle of Aryan civilization and also the scene of battles

(1) L. W. Lyde: Continent of Asia, p. 408.

and were far removed from the ~~enormousness~~ of the sea in the east and west. Still it was here that direct communications to the east and west were possible and also to the north and south through the gaps in the mountain chains.

The sacred and mighty river Ganges flows through this country majestically giving the life water for the growth of crops. No wonder that the Hindus hold this river in such high esteem. Towns sprang up on its banks and became the sacred places of the Hindus. Hardwar, Allahabad and Benares on the banks of the Ganges are still the centres of pilgrimage. Hundreds and thousands of devotees gather at the banks of this river to have a dip on the occasions of festivals.

Of all the provinces of India, this is veritably the land of gardens with soils of unequalled fertility. It is protected against the floods with natural high sandy ridge contrary to Bengal. The western part of the Province with a poorer rainfall and greater variability is protected by a network of canal systems to fight the adversities and droughts. Because of lower rainfall in the western districts and hence difficult working of the fields, nature in its bounty ~~merely~~ has given to this part a hardier type of people in Jats and Thakurs and also better cattle which make the agricultural work easier than otherwise. They are ever ready to cope with any type of climatic vagaries and to assist to build up the high standard of agriculture exhibited in this part. As this Province had been the scene of

great historical activities in the past, we come across an unusually perfect system of internal communications in the form of roads and railways.

The fine but rigorous climate of the western part of the Province has helped in breeding a hardy ~~people~~ ^{people} capable of enduring the extremes of climate. The dryness of the climate has given prominence to the question of water-supply. The success or failure of a crop in western U. P. depends on water-supply. Thus, naturally, prior to the introduction of modern elaborate schemes of irrigation, the rivers were the main deciding factors in the allocation of agricultural areas as well as in the distribution of population. The rains at the opportune moment were most welcome. The winter rainfall, insignificant as it is, is enough for spring crops, provided the falls occur at the right time. But the delay or failure of monsoons means a grave anxiety to the farmers, they may even cause complete disaster and hence the intensity of famines due to drought in western U. P. and Bundelkhand.

On level plains such as the Gangetic plain, the surface drainage is slow ^{whereby} ~~and hence~~ the soluble constituents, rich in plant food, are not washed away. Thus in drier parts there have been tracts with soils of great fertility but the scanty rainfall and high watertable confined the cultivation to the river valleys. The possibilities of development of such areas have been demonstrated in western U. P. by the introduction of modern irrigation schemes

by the British government.

In spite of the fact that great diversity in climate and physical aspects is exhibited still the Province is unified fundamentally on the basis of language, though dialectical differences occur. Density of population depends on rainfall, soil and facilities for irrigation throughout the Province, but the type of settlement differs from place to place. In the west people have congregated into villages and in the east scattered settlement seems more to be a rule than exception. In the north, linear settlement along a river is visible whereas in the south the most important factor that governs the settlement is the soil; wherever ^a thick mantle of sub-soil ^{and so a supply of water} is available the settlement grows.

To give a scenic idea of the country to be dealt with in the following pages, it is necessary for the readers to understand that the Gangetic plains are the most densely peopled part of the Province and the life of the inhabitants depends on the plains. During the rains they look like a carpet of green verdure spread on the rolling plains. It is green to such an extent that it presents to the eye a dull monotony of greenness. Water hides beneath the green grass during the rains and is drained off during the winter. For 500 miles from east to west and 200 miles north to south, whichever direction he may travel, one notices nothing but a velvety sheet of green vegetation. With the approach of ^{hot months} ~~summer~~ the green vegetation starts turning

yellow because of dessication. Eventually the grasses and shrubs begin to die out and finally a dull greyish appearance of the soil is noticed with purple shrubs and grasses here and there that have escaped death.

The object of this inquiry is first to analyse the physical aspects of the country, its climate and soil. The next attempt is to analyse the human efforts towards the improvement of soil by irrigation, manures and rotation of crops, etc., and finally how he has tried to free himself from the vagaries of weather by irrigating fields where rains have been in defect or draining the fields where they ~~xixx~~ have been in excess. Soil, water-supply and physical aspect of a country are the main factors which govern the production of an agricultural country and hence an effort of study and analysis has been made on these limiting factors. The present agricultural practices have been analysed and the influence of physical aspects on the agricultural settlement has been discussed. The ease of communication in the form of roads and railways has also been discussed because on this depends the economic aspect of agricultural industry. The country being predominantly an agricultural one, main crops and the cattle problems have been studied on the basis of agricultural regions. Finally a review has been made how the development of agriculture could be made on modern improved lines to solve the problem of ^{the} teeming millions of its population and how far the present methods of agriculture are fulfilling the obligations of

its peoples who are directly or indirectly dependent for their living on the soil and art of agriculture.

The chief feature of the present inquiry has been the preparation of maps to show the real economic and agricultural conditions and also to show the dependence of agriculture on its physical basis and how far human efforts have succeeded in mitigating the vagaries of nature and remedying the evils caused. It will not be out of place to give an idea of time and labour involved in the preparation of these maps. The land utilization map 1/M has been made from about 250 sheets of half-inch maps which has involved a labour of more than a month. The original soil maps of the eight districts prepared on the basis of rental value from the settlement reports have taken about two months as this has involved a study of about 70 settlement reports beginning from the second half of the last century. The climatic and agricultural regions similarly have involved a lot of time on the part of the writer. The working of the statistical averages to prepare the agricultural maps took him no less than three months.

In the N.W. the U. P. borders with Nepal to the north, distance, with Bihar to the east and the Ganges forming the boundary to the south. The Ganges-Jamaa virtually identical with the right bank of the Ganges and the province of the Punjab including the province of Delhi to the west.

PHYSICAL ASPECT.

CHAPTER II.

Scope:- The United Provinces occupy the north central part of the Indian Empire. The Province lies between latitudes $23^{\circ} 52'$ and $31^{\circ} 18'$ N. and longitudes $77^{\circ} 3'$ and $84^{\circ} 38'$ E. and has an area of 112,191 square miles.

The central portion of the Province comprises vast alluvial plains formed by the river Ganges and the Jumna on the west and extends towards the east by the Gogra and the Rapti. On the north the main physical feature of the Province is the snow covered peaks of the Himalayas, a portion of which falls within the Province on the north west while other parts are never far from the provincial border. In the south-west the Trans-Jumna tract gradually merges into the central Indian plateau and Vindhya Hills. In the south-east of the Trans-Ganges tract, comprising a little bit of the district of Allahabad and the greater portion of the district of Mirzapur, are the Vindhya plateau and Kaimur Hills (a continuation of Vindhya and Satpura Hills).

In the N.E. the U. P. marches with Nepal for a short distance, with Bihar on the east and the water parting of the Sutlaj-Jumna virtually identical with the right bank of the Jumna and the province of the Punjab including the province of Delhi on the west.

RELIEF.

The Province can be divided into the following Relief regions:-

1. The Montane Tract.
2. The Sub-Montane Tract.
3. The Plains.
4. The Trans-Jumna Tract or the Central Indian Plateau.

The whole of the alluvial plain is formed by the Ganges and its tributaries and has been referred to for the purposes of the present inquiry as the Gangetic plain. Normally the term 'Indo-Gangetic Plain' means the vast area covered by the alluvial deposits of both the rivers, the Indus and the Ganges, but in the present discussion it is only the alluvial deposits of the Ganges (included in the area of the present inquiry as defined above) which are dealt with. Moreover the deposits of both the rivers differ to a material extent⁽¹⁾ .

The Montane Tract:- This is the northernmost region of the Province and includes the districts of Almora and Garhwal (including the Bhabar and Tarai)⁽²⁾ Chakrata Tahsil⁽³⁾ of the Dehradun district and the hill patts of the Nainital district and also includes the Native state of Tehri. This is the mountainous portion of the Province rising abruptly to a height of 6,000 - 8,000 ft., and the ranges are some 50 miles wide. These ranges are usually thickly wooded to their summits and the chief income/

(1) Record of the Geological Survey of India, Vol III, pp.17 and 18.

(2) Bhabar & Tarai will be described later.

(3) Tahsil, i.e. a sub-division of a district.

income to the state is from the forests. They are still the home of tigers and elephants, and are very thinly peopled. Scattered agriculture is carried on here and there, and the chief crops are rice, wheat, barley, maize and tea. This tract comprises many minor parallel ranges which have deeply undergone the cycle of erosion by rivers. The most common rocks found in this region are limestones, and ^{metamorphic schists.} ~~slates of granitic character.~~

The Sub-Montane Tract:- This region is south of the Montane Tract. It includes the remaining parts of the Dehradun, Nainital, Almora and Garhwal districts and also includes the northern damp forested parts of the districts stretching throughout the whole length of the Province on the foothills of the mountains, from Saharanpur on the west to Gorakhpur on the east. This sub-division is mainly composed of a narrow fringe of low-hill rocks varying from Nummulites to Miocene Siwaliks. The Siwaliks are built up of soft conglomerates, sandstone and clay and are a feature lying south of the Himalayas throughout its length in the north-west. Physically they are an intermediary line of broken hills of recent origin lying between the Himalayas and the plains. The upland valleys between the Siwaliks and the Himalayan foothills are called the Duns. They are very fertile and are known as the fruit gardens of this Province.

The Bhabar is a peculiar formation of gravel and shingle of a very spongy texture where the great torrents pour down and are lost beneath the gravel and reappear again in the Tarai. The Tarai is a damp marshy tract south of the Bhabar due to nearness of/

of sub-soil water, high humidity and high rainfall. The Tarai forests extend from the western border of the Province. "They are the most deadly of all the fever-haunted jungles of Northern India"⁽¹⁾. They are covered with stunted jungle shrubs and tall grasses. The population is migratory. The Tarai soils are very fertile, and where the forest has been cleared a settled population is established. The Tarai between the Ganges and the Jumna is insignificant, probably because of good natural drainage. As one advances eastwards it becomes more and more pronounced. West of the Ganges the deposition process in the Siwaliks due to river action has been so great that excavation of this tract for the construction works of the Eastern Jumna Canal brought to light the ruins of an ancient town ⁽²⁾.

Gangetic Plain:- South of this region is the Gangetic plain (as defined for our purpose above) a vast expanse of the deposits of the Ganges and its tributaries. It is bounded on the south by the river Jumna until its confluence with the Ganges. This alluvial deposit consists of a sandy micaceous calcareous clay⁽³⁾. Older alluvium can be distinguished by a nodular segregation of carbonate of lime ⁽⁴⁾. For 8 or 9 months in the year the great rivers rush down the mountain gorges bringing clear water but in the hot months the water is charged with fine glacial mud. During these months therefore the rivers cut their channels.

(1) I. G. of India, Vol. I. p. 17.

(2) Records G.S.I. Vol. VI, pt. 1.

(3) I.G. of India, Vol. I.

(4) Oldham: Geography of India, p. 437.

During the floods the opposite happens. The river water fully loaded, deposits its detritus wherever the slope is insufficient. In other words the Khadar lands and the channels which have been deeply cut due to the movement and the flow of the river, receive the greatest portion of the flood deposits. Though the Khadar is really an alluvial land, it is likely that it is undergoing denudation (1).

The Gangetic plain within the Province is about 500 miles long from east to west and about 150 miles broad from north to south. The general tilt of the plain area is from north-west to south-east with a gradient of about 1.5 ft. per mile. (From Saharanpur on the north-west to Benares on the south-east, the distance is about 450 miles and the fall in level about 650 ft., giving a gradient of 1.5 ft. per mile (2)). Flat country like this has its own advantages. The rivers move slowly and hence deposition of fine silt is accelerated which means better soil fertility and hence agricultural prosperity. Evenness also affords facilities for water ways and for the introduction of irrigation canals. It also determines the courses of the numerous streams that flow through it. The evenness maintained throughout the length and breadth of this alluvium will be seen in the cross sections taken across certain rivers which are described later.

The disadvantages of the flat nature is exhibited in the shape of floods. With the advent of summer, when the snow in the mountains/

(1) Records G.S.I. Vol. VI., pt. 1.

(2) Benares 258 ft., Allahabad 319, Cawnpore 417, Agra 553, Delhi 715, Meerut 739. and Saharanpur 902

mountains begins to melt, the rivers become heavily charged with detritus which is brought down from the mountains then, and during the rainy season. The coarser material is deposited at the foot of the mountains where the gradient is the greatest. The lighter particles are deposited on the land with less gradient. These floods cause havoc to the cultivators by bursting the banks and devastating the fields, uprooting trees and depositing them at unwanted places, taking away the fertile soil and depositing it in useless areas. In the sub-Montane districts the gradient is greater than that of the plains the gravels and the sands are deposited at the first point where the current is checked, and hence the soils are of a lighter nature in that tract. As the slope gradually diminishes and the rivers cross over to the plain, the finer particles of soil which the river is now carrying are gradually deposited and the soils get stiffer as the rivers advance from north-west to south-east.

The Khadar (flood plains) of the Ganges and Jumna are usually 2 to 4 miles broad and are below the general level of the surrounding country. This is a ribbon of annually flooded land with ever shifting river channels. The rivers carve out new channels leaving their old beds or may reverse the process and follow an abandoned old course. There is a constant change in the shape of the meanders. Old ones become 'cut off' but already new ones are being born. Such is the usual process with rivers within this meandering belt of the flood plain. The land beyond the/

the influence of flood is level. The Bangar ('upland' or the Gangetic plain proper) not very long ago had also been the playground of the erratic rivers but has obtained a considerable amount of safety due to the establishment of the high banks on either side of the big rivers and redissection from 50 to 100 ft. below the level of the plain. Doabs (upland between 2 rivers) rise from the banks of the two rivers within which they are situated and end in central uplands. A line of swamps may be traced from Aligarh to Farrukhabad which can be identified as the old bed of the Ganges and is now known as the Burh Ganges. Flooding streams cause destructive floods and damage to life and property and can therefore sometimes be the greatest enemies of the cultivators. The most frequent damage is caused where the rivers are not protected by high banks. The cutting action of the river is not constant because for nearly half the year there is nothing but a series of swamps hence the broadening of the valley has not been possible. The result is a sudden outburst in the rainy season.

The Trans-Jumna Tract:- To the south-west of this tract are situated the Rajputana Highlands and the rivers in this area flow from south-west to north-east. The drop in the level of the plain does not exceed 2 ft. per mile. The rivers emerging are charged with gravels and even stones of considerable size. The small streams are fed by rain or by drainage by irrigation and are dry in the summer.

The/

The tract is distinguished by its plateau character and the differences in the soil. It lies on the low-lying spurs of the Central India plateau and is broken by the outlying spurs of the Vindhya Hills. The major portion of the tract is covered with stunted forests. It has the form of an undulating dissected country. Ravines on the river banks are a predominating feature.

The district of Mirzapur has a poorly developed agriculture due to the rocky nature of the soil. The tract between the Ganges and the Son belongs to the Vindhya plateau, south of which is the hilly tract of Kaimurs.

Map at fifty feet interval was prepared by correlating soils of the province with the map of the Survey of India. Assuming this correlation to be correct, the map was prepared upon a compilation of contour maps of the province. The method adopted was that the ground level heights were put down upon 1/4 inch base map from the Survey of India sheets. The whole area covered by the Gangetic alluvium in the province. Four types of ground level heights were put during the course of compilation of this map - (a) ground levels at different points (b) triangulation points marked in the Survey of India sheets (c) spot levels marked, and (d) railway levels kindly supplied to Dr. Gaddes by the different railway companies of India.

Spot levels were recorded which were corrected by a study of the general level of the country as

Contour map of the United Provinces.

So far the United Provinces had only two hundred and fifty feet, five hundred feet and one thousand feet contour lines drawn, which served but little useful purpose for a critical study of relief. The Gangetic plain comprised within the province rises from a height of two hundred feet to about nine hundred and fifty feet above sea-level. This means therefore that the main agricultural land of the province lies within two hundred feet and one thousand feet contour. It was thought that compilation of a contour map at fifty feet interval would be a great help towards correlating soils of the province with relief and land use.

Assuming this correlation as the basis the writer embarked upon a compilation of contour map at the above interval. The method adopted was that the ground level heights were put down upon 1/M base map from the half inch sheets on the whole area covered by the Gangetic alluvium in the province. Four types of ground level heights were met during the course of compilation of this map - (a) ground levels at different points (b) triangulation points marked in the Survey of India sheets (c) canal levels marked blue, and (d) railway levels kindly supplied to Dr. Geddes by the different railway companies of India.

Sometimes anomalous levels were recorded which were corrected by a study of the general level of the country as it/

it was the only means of correction and therefore allowed no choice. In a level bit of a country triangulation points were in harmony with other levels but in an undulating country, the triangulation points were mostly recorded on the edges of sandy Cliffs or other relative upper grounds. Therefore the level was corrected by deducting the height of the Cliffs. The bridge points were also similarly treated. The use of relative heights marked \sim in the half inch maps were also fully utilized to make the contours as real as possible. All possible breaks of slope were taken into account.

A comparison of five hundred feet contour drawn by the writer and that of the Survey of India gives illustrations of how the Survey of India have exaggerated the contours near the rivers. Besides, this particular contour seems to have been drawn by draftsmen who are not well-versed with the countryside and have only done mechanically without paying any regard to the technique of the surrounding land which has resulted in altogether a new five hundred feet contour. The two hundred and fifty feet contour similarly was very much exaggerated at the R. Gogra, whereas it was minimised at the Ganges and this has also been corrected in the new contour map drawn by the writer.

About five or six miles east of the Ganges at latitude approximately 26°N. , the remains of the old bed of the Ganges are exhibited in the form of depressions and hollows of /

of O, C, & S, shapes, which are annually filled with water during the monsoons. Here the contour swings northwards and gives a clear indication of a low lying land at the point of swing and behaves in the most ideal way. It affords with a reasonable certainty a forecast of the type of soils to be met with, with this depression. Such points have been especially regarded while the soil groups were being deduced.

The upper course of the ^{GANGES,} after emerging from the hills is approximately N - S, the contours in this area are east and west. Later the river takes N.W.-S.E. direction, the contours run N.E.-S.W., and finally river takes an east west direction where the contour runs in a north south direction. In all the above cases the contours are running at right angles to the river, very clearly elucidating the origin of the alluvium as brought down and deposited by the Ganges.

The Ganges has carved out a definite terrace and at places more than one is noticed. The uppermost terraces are usually free from flood but the lower terraces are practically annually inundated. The Jumna is not so predominant in carving out terraces, though a three terraced descent just south of latitude 28° N. is noticed. Ten or twelve miles east of the above ^{terrace} ~~latitude~~ can be noticed an appreciable amount of sand running in ridges, the origin of which is doubtful but a study of the movement of the Ganges will convince that although the above described sandy ridges are nearer to Jumna than Ganges still they form part of the Gangetic sand. What-
ever may have been the origin of this sand, one thing ^{which} cannot escape notice is that within this belt of sand there is no sign of settlement.

DESCRIPTION OF THE COUNTRY
AS ILLUSTRATED BY SECTIONS. (1)

If a section through the Ganges is taken in the Saharanpur and Bijnor Districts (see section 1), we find that the general tilt of the country is from N.W. to S.E. as is illustrated by the few spot-heights. If we draw a line S.S.E. from Saharanpur at 900ft. we find that it passes through Nagal at 880ft., Talheri Bugurg 861ft., Deoband 836ft., and Rohana about 825ft. (All these towns lie on the N.W. Railway and the heights have been taken from the $\frac{1}{2}$ inch map). The distance from the first to the last station is roughly 28 miles so that the slope is approximately 2.6ft. per mile. Such a slope is normal on a level alluvial plain and hence the Gangetic Plain has often been referred to as a 'dead-level plain'.

Bordering the Solani river, just before it enters the Ganges on the right bank, are found numerous lakes which are covered by flood-water only occasionally. They are situated 30 miles S.E. of Saharanpur. As we descend from the west bank (i.e. of the Ganges) there is at first a sudden drop of 100ft. in $\frac{1}{4}$ mile (see section 1). There is therefore considerable ravining until the lakes described above are reached near the Solani river. The latter are about a mile distant from each other, the intervening land rising on an average about 15ft., and being ravined to a certain

(1) For the soils covered by the above sections, please refer to Soil map No. 6-13.

extent. In these ravines and in those of the upper terrace edge, there is nothing but waste scrub, with not a sign of a tree to break the monotony of the landscape. The level begins to rise again away from the lakes by about 12ft. in the first half mile. Here again waste scrub is predominant and habitation is conspicuous by its absence as it is also in the ravined terrace and intervening sandy wastes among the lakes. Continuing eastwards for another $\frac{1}{2}$ mile we are able for the first time to see signs of habitation as well as cultivation in spite of the fact that we are still on the true flood-plain. Cultivation in this tract is endangered by flooding if the rains have been normal or in excess so that a good crop can be harvested only if the rains have been below the average. After about $\frac{3}{4}$ mile such a landscape gives way to the flood-bed of the Ganges proper. Thereafter two or three side-channels of the main river have to be crossed before there is an appreciable rise. The main channel at this point is about 500ft. in width.

Generally speaking the few habitations found in this $\frac{1}{2}$ -mile zone of waste scrub and occasional cultivation, are those of the poorer cultivators most of whom are immune from malarial epidemics.

Still further east the land rises 70ft. in 4 miles. Dwellings are found after $\frac{1}{2}$ mile although cultivated areas

begin after $\frac{1}{4}$ mile. The latter is very uncertain and as a result the habitations are not of a permanent nature. When 70ft. above the river is reached (i.e. after 4 miles) we meet for the first time temples indicating the permanency of the habitation. Thereafter the Gangetic plain stretches for mile after mile, the usual monotony only broken now and then by some bed of an intermittent stream, a railway bridge, or a canal.

In the same latitude, but about 28 miles to the west of this part of the Gangetic plain (see section 2) flows the Jumna, a very big right bank tributary of the Ganges. Here the general lie of the country is from N.E. to S.W. in contrast to the N.W. - S.E. tilt of the country discussed above. In the northern part of the area under treatment are the mighty Himalayas from which the plains slope down in two directions, one towards the S.E. and the other towards the S.W. In the S.W. flows the Jumna and in the S.E. the main river of the Province, the Ganges, while the Doab is a natural upland (1) plain wherein is to be found the cultivated land of the Province. If we travel southwards along the line of the Eastern Jumna canal we are able to test the reality of the fact that the slope of the country is from N.W. to S.E., e.g. Dheri is 885ft. above sea-level. Dakrawar Kalan 880ft. Salempur 863ft. Sahjod Sidhauri 860ft. The distance between the first and last

(1) "Upland" is only a relative term meaning "at a higher level" and is not intended to suggest hill country.

village is about 10 miles so that the gradient is about 25ft. in 10 miles or 2.5ft. per mile. The slope of the country is therefore very similar to that found in the previous description of the Gangetic plain. The Jumna river banks show a 'badland topography' ^{as a result of} which ~~means that~~ ~~for a distance of about 2 miles~~ the valley of the Jumna is ^{for a distance of about 2 miles} surrounded by forests intermixed with tall grasses which serve as tracts for cattle breeding and as grazing area for the milk animals. Beyond the forests for about 5 miles on either side of the river are the scrublands interspersed with Usar (alkaline) lands formed where there is improper drainage. The improperly drained area is coincident with the area of badland. 5 to 6 miles further east we come across a drainage channel known as the Katha Nala which helps greatly to drain the land but even then it leaves large areas untouched so that cultivation is largely impossible and the country is given over to waste land producing nothing but scrub and a few leguminous trees. Babul (*Acacia Arabica*) is a leguminous tree common in such areas and it is important by reason of its threefold utility since its bark gives us ~~gum arabic~~ and tannin which is used in curing the hides. The third and most important function of this tree is the fixing of the atmospheric nitrogen which helps the bacterial growth of the soil and hence is of great importance to agriculture. Within this

scrub area we do not come across any important towns or large villages because agriculture, the main occupation in the Province, is not prominent in this area. After crossing the Katha Nala drainage channel, about a mile eastwards we come across big villages because the country here is mainly agricultural due to better drainage conditions. This area is in the typical upland Doab region. It is here that we come across important agricultural towns and these continue till we reach the Eastern Jumna Canal. After crossing this the land is almost given over to agriculture, with big villages and small towns scattered around and acting as collecting centres for the agricultural produce. Around the villages and towns we have the temples and mosques which show the permanency of habitation. The largest towns are joined by a one metre gauge railway which carries the agricultural commodities for export.

Our section (No. 3) drawn in a S.W. - N.E. direction across the Ganges at a point 10 miles below Farrukhabad, shows that the country in the S.W. is highest and that the level drops to the N.E. Between the Ganges and the Ramganga valleys the lowland is almost continuous and is intersected by smaller streams and side-channels of the two rivers. This intervening land rises no more than 12-15ft. above the normal level of the rivers and is approximately 6 miles broad. The vegetation covering is not the same

throughout. For about $\frac{1}{4}$ mile to the east of the Ganges we find a belt of Tarai forest mixed with grasses, the whole acting as a grazing area. Due to the narrowness of the strip, the animal population is not very large. Beyond this forest belt we come to cultivated land followed by a patch of waste scrub and then once again cultivated land intersected now and then by dry river beds which contain water only during the rainy season. The distribution of cultivated and waste areas is purely accidental and depends entirely on the quality of the drainage, the cultivated areas coinciding with the better-drained parts, and the waste scrub with the less favoured tracts. On this flood plain big villages and towns are absent because of the precarious nature of the agriculture due to the changes from disastrous flooding, and the map shows only a few scattered hut signs. If the rivers deposit good silt on the sandy soils, it results in increased cultivation of a good quality but if sand has been deposited on good loamy fields, the cropped area is naturally reduced. The district of Farrukhabad is a typical example of a country having an intensive cultivation. The tract is naturally fertile and night soil is freely used as manure. These conditions, as we know, favour intensive cultivation. Another favourable factor operating in this tract is the special three crop rotation in one year which is probably

the most the soil can yield in one year. This intensity of agriculture results in a dense but dissiminated population, there being a habitation for every 2 acres or so. The rise from the valley of Ramganga to the plain eastwards again is not so great as is the rise of the level from the valley of the Ganges to the plain westwards. As before, beyond the valley proper stretches the vast level Gangetic plain broken only here and there by mango groves, canals, smaller streams, railway lines or forest patches.

If we cross the Ganges about 25 miles below Cawnpore (see section 4) from Bindki Road in the S.W. towards Bhagwantnagar in the N.E. we find that for the first 5 miles there are level plains. Patches of cultivated land, jungle and scrub cover the land until we come to the ravines near the cliffs about 35ft. below which flows one of the side streams of the Ganges. About 10ft. above the normal level of the water^{of}/the river is a flood plain varying from 1 to 2 miles in breadth, the greater part of which is not cultivated due to the sandy nature of the soil. The cultivated parts of the flood plain grow zaid crops (melons, water-melons, cucumbers, etc.) No stable cultivation of pulses or grains is carried out due to the insecurity of the land. The zaid crops are usually not grown on an extensive scale, but occupy the small patches of good but insecure land. Long patches of good alluvium which could be

utilized for stable cultivation are not to be found here.

The general slope of the country is from N.W. to S.E. as will be evidenced by the following details. Namana in the N.W. is 431ft. above sea-level and Khiron in the S.E. at a distance of 28 miles from the former is only 373ft. above sea-level. The drop is about 2ft. per mile which is very gradual and quite normal for the Gangetic plain. From Bindki Road 394ft. in the N.W. to Malwa 384ft. in the S.E. is a distance of about 10 miles. The slope is therefore only a foot per mile. Between the last mentioned two stations the slope is rather less as compared to the rest of the Province, the result being that the Ganges within this area has carved out many side streams and hence a greater flood plain. The cultivation of the flood plain is exactly similar to that described above, the houses being very few and scattered and of a temporary nature. After crossing the main channel of the Ganges the level of the land rises but with the rise in level we notice some ravining. After crossing the ravines we come to the plain proper of the Province. In the first part of the plain, that is to say, just after the ravines are the jungle lands. They are the result of the greater rainfall combined with a shallow water-table due to the nearness of the river. The ravining is caused by the excess of water from these jungle lands draining comparatively steeply towards the Ganges,

helped of course by the soft nature of the ground. After the jungle comes the level cultivated land alternating with Usar/⁽¹⁾lands caused by the lack of gradient in the plain.

These Usar lands which produce nothing but the Babul trees are utilized for building purposes. Large tracts cannot and, as such, have not been utilized for house building purposes because bigger tracts make the distance longer to the cultivator's plots. In this part of the plain the abundance of S and O shaped lakes indicate that once some meandering river flowed through this region. Around these cut-off lakes we find forests of limited extent, while rice cultivation is common in the shallow water of these lakes.

If we cross the Jumna about 16 miles S.W. of Fatehpur from north to south we find that the slope of the country is from north to south in the north of the river and south to north in the south of the river, that is to say a normal river 'valley' (see section 5). The valley of the Jumna is the real low-land between the upper plains in the north and the south. The slope for a distance of 12 miles from Murawal (384) to Datranli (349) in the south is about 3ft. per mile which is slightly more than the normal for the Province. Similarly the slope for a distance of about 10 miles from Bardara (388) to Lalanli (354) on the north of the river is about 3.4ft. per mile which is also above the normal for the Province. The slope from west to east is

(1) Usar Lands are the Bald Patches Suffering from excessive Alkali Deposits.

very little e.g. from Lalanli (354) to Jaranli (336) a distance of 20 miles, the slope is less than a foot per mile which is below the normal, the result being that the river takes long meanders across a very wide flood plain.

The area south of the Jumna seems to be more ravined than the north due to the rocky nature of the land in the south. Ravining naturally results in a 'badland topography' although recently afforestation on stream and river banks has been adopted to check it. Afforestation to check ravining was suggested by the Royal Agricultural Commission in India, the utility of which has yet to be seen, though the writer believes that it must show good results and probably has shown such results in one or two places. Within a radius of 5 miles from Fatehpur we are able to see innumerable lakes of S and O shapes which clearly indicate the former beds of old rivers. Sasur Khader Nadi has left a long meandering curve about 3 miles west of the above mentioned town. This 'cut off lake' as we should call it has permanent water in it and is joined to the main river only during the rainy season. A number of intermittent lakes have been brought under paddy cultivation though quite a number of them are left barren either because the soil is not suited to agriculture or because they are too low and become flooded too much during the rains. Because of the presence of these low-lying hollows, the rain-water from the neigh-

bouring plains gets an easy outlet. The excess of water in the sub-soil found elsewhere is not a problem here. In fact the easy drainage coupled with the smaller rainfall has resulted in little agriculture, due to water deficiency in the sub-soil. The Fatehpur branch of the lower Ganges canal has been constructed to irrigate such lands but areas at a great distance from these distributaries do not get their proper share of irrigation and hence we get the comparatively greater acreage under waste in this part of the Province. Alkalinity is a problem near the canals because of seepage. The best land is therefore neither too near nor too far away from the canals.

The settlement is more of a village type than scattered but a minute scrutiny will tell us that both types of settlement are present indicating the transitional nature of the zone. Large villages are about 5 to 6 miles apart and between them are to be found groups of hamlets studded at intervals. Scattered settlements about 3 miles south of the river show that these are the newer type of settlement placed where ravining though not completely stopped has been minimised, these settlements being beside the ravines themselves. The ravines have begun to be cultivated which in turn has given rise to a scattered settlement. Temple signs on the map about a mile from the river sands indicate the permanent nature of the type of settlement though we

cannot definitely affirm this because one or two temple signs can not be a sure proof of the permanency of settlement. There is no doubt that settlements are to a large extent at the mercy of the river.

A section (see section 6) drawn across the Ganges a few miles downstream from Benares shows that about 11 miles north of the Ganges flows the Gumti river which joins the main river about 15 miles N.E. of Benares. The general slope of the country is from S.W. to N.E. Khunchman in the west is about 273ft. above sea-level and Barahni in the east at a distance of about 15 miles from the former is 242ft. above sea-level. The drop of the level is therefore 2ft. per mile which is not very much above the normal for the plain's area of the Province. Singhitali about 8 miles south of the Ganges is at a height of 289ft. above sea level and Dufferin Bridge beside the Ganges is 275ft. The slope from south to north therefore is about 1.8ft. per mile which is normal. From Dufferin Bridge to Kanchaman eastwards the drop of level is only 2ft. in about 11 miles. This drop of level is so little that the river meanders considerably with the usual accompaniment of cut-offs both C shaped and O shaped. For about 10 miles north of the Ganges cultivated land alternates with waste land unfit for cultivation, mostly of alkaline nature. As before these alkaline areas are due to improper drainage which allows

standing water with consequent excessive evaporation, drying out the salts and giving rise to sterility and therefore scrub. The dwellings in this region, as is also the case to the south of the Ganges, are of scattered type and big villages are conspicuously absent. This is the typical characteristic of the habitation in the east based mainly on agricultural and historical considerations (see below). In the west we find stronger cattle and the cultivators use them for carting manure to the distant fields, the cultivators in the west believing in equally manuring all their fields. On the other hand, the carting of manure is a big problem for the eastern cultivator since his cattle are not so sturdy. The net result is that the majority of the eastern cultivators/^{not} having any carts have built their houses on or near their fields. From the time of Lord Cornwallis the cultivators have enjoyed 'permanent settlement' a law by which increment in rent is not possible, hence they have stuck to their land and have built their houses near their fields. The disseminated nature of the dwellings in the east has also been brought about by the nature of the history of the region and this is probably the most important reason of all. East was comparatively safer from attack than the west, the result naturally being a compact settlement in villages in the west and scattered in the east.

The river at this point is from a $\frac{1}{4}$ to $\frac{1}{2}$ mile broad and

has cut an appreciable amount of flood plain varying from a half to 2 miles. A few scattered houses are to be seen between the two channels of the river and cultivation is carried on though precarious, as the agriculture in this region is at the mercy of the river. Mainly Zaid is cultivated and sometimes rice of an inferior type is also cultivated though juar crop in such a region is not uncommon. The settlement between the flood plains of the two channels of the Ganges at this particular locality seems to be of a somewhat permanent type judging by the presence of temples. The few scattered houses seem to be fairly safe from the ravages of the flood because of their higher situation than the true flood plain. For about 12 to 15 miles south of the Ganges the level of the plain rises gradually until the district of Mirzapur is reached where it suddenly increases because of its rocky nature. Cultivated patches alternate with waste patches. These wastes seem to have been once lakes and prior to that probably they were the courses of smaller streams. Some of these low-land patches have been brought under cultivation of rice others though still wastes might in future be brought under cultivation. The settlements, similar to the north of the Ganges, is scattered. For about 15 miles north to south we see a number of temples probably because of the nearness to the holy town of Benares. Both the banks of the river

are studded with temples.

If we cross the Gogra river from south to north (see section 7) from a point about 10 miles north of Azamgarh town we meet about 5 minor streams before we reach the banks of the Gogra river. We notice in this region the following important facts:-

1. That the percentage of land under wastes is very little as compared to other places mentioned so far. The chief facts which account for this are (a) that the number of minor streams is greater and hence there is better drainage of the undesirable standing surface water. (b) There are no canals to bring dissolved salts to the surface resulting in alkali lands. (c) The density of population is very great being nearly 800 per square mile with the result that pressure of population brings the marginal lands also under cultivation.

2. A typical disseminated settlement is visible for which an explanation has already been advanced, namely, the intensity of the agriculture.

3. The variability of the monsoons is not great hence a greater security for successful cultivation.

4. 'Permanent Settlement' has given practically the proprietary rights of the land and has thereby fostered improvements to the soil resulting in still further increase in population.

5. Less acreage under forests is a visible feature. The main forest patches are on the river banks and very little on the alluvial plains. The reason is that natural drainage, good soil, abundant rainfall and higher density of population have tended towards the extinction of forests, i.e. the forests have been cleared and replaced by cultivation.

The river is as wide as the Ganges and at places even more and carries an equal volume of water if not more. The last fact can easily be inferred from the plying of ferry steamers in its water. The flood-plain is also very broad as a consequence. The river has carved many side channels within the flood plain. Level drops from west to east. Drop in level is so much that the river has formed many meanders with O and S shaped lakes. Shallow lakes have been brought under the cultivation of rice. Some of them grow only reeds while others, that are not suitable for any of the above purposes, are left without any use.

The country north and south of the river is nearly the same, the only difference being that there are more lakes and abandoned courses of the smaller streams in the north than in the south.

RIVER REGIMES

Ganges:- The Ganges takes its rise in the Tehri State latitude $33^{\circ}55'$ N. and longitude $79^{\circ}7'$ E. from an ice cave near Gangotri, 13,800 feet above sea-level. It receives the Alaknanda on its right bank and the united stream after cutting the Himalayas emerges to flow south-eastwards to Hardwar. Thereafter its course is always through lowland areas. In its upper course it serves as the boundary between the Meerut and Rohilkhand divisions and later on between the latter and Agra Division and for some distance between the Lucknow and Allahabad divisions. It then passes through the district of Allahabad. Mirzapur, Benares and Ghazipur and finally acts as the provincial boundary between Bihar and United Province.

It is by far the biggest river of the province and receives some of the big tributaries such as the Ramganza, Jumna, Tons, Gunti and Gogra. The river has been tapped at Hardwar for the Upper Ganges Canal and again at Narora for the Lower Ganges canal, but the supply of water is replenished by the above important tributaries. It is also the source of water supply for important towns like Meerut, Cawnpore and Benares.

Important changes still take place due to the movement of the river. It periodically leaves its old bed and carves out new channels through which it starts flowing majestically, ^{which} and sometimes ^{are} ~~the new channel is~~ at a great distance from the old ^{ones.} Changes of such a nature are extensive and the horizontal cutting action of the river is so great that it is considered most/

most dangerous to build structures of a large or permanent character on the river bank. During winter a clear narrow ribbon of water flows through the channel which in the rainy season assumes a menacing appearance as a brown swollen torrent. It is during the rainy season that activities of the nature of carving new channels and leaving the old course etc., take place. The speed of the river is tremendously increased and it is not uncommon to see uprooted trees floating down the river during the floods. An unusually heavy flood causes considerable damage to life and property. The chief feature of this river is that it is less harmful to the cultivators than it otherwise might have been because it is protected by a high sandy ridge which does not allow of any appreciable damage to the villages beyond it. It is the flood plain which suffers the greatest damage during the flood time. Dwellings of a permanent nature are not to be seen within that area. An appreciable amount of cultivation of Zaid crops (melons, cucumbers etc.,) is carried on in the sandy tract wherever manure is available. Hardwar, Cawnpore, Allahabad and Benares are the important towns on its banks. Allahabad where the Jumna joins the Ganges is held in high esteem by the Hindus.

The Ganges formed the sole line of traffic until the middle of the last century. After the introduction of railways which provided quicker means of transport the trade on the Ganges decreased considerably. Only the bulky commodities such as wood, grains, sugarcane and stones etc., are still being carried by the Ganges. Cotton was a very important article which used to be conveyed/

conveyed to Calcutta from the United Provinces, Central India and Central Provinces before the introduction of railways. The canal dam at narora has cut off the traffic between the upper and lower courses of the Ganges.

Ramganga:- The Ramganga rises in latitude $30^{\circ}14'$ N., and longitude $80^{\circ}71'$ E., a little south of the snow clad ranges of the Himalayas. From here to Bijnor a distance of about 90 miles the river has a tremendous gradient until it enters the plain country. The river is liable to sudden floods because of heavy rainfall in the upper reaches. The river runs through ever-shifting channels leaving large islands of sand between the channels.

It passes through Moradabad district and then through the state of Rampur and finally through Bareilly district. The direction is south-eastwards as far as Bareilly, after which it follows a southerly direction and joins the Ganges at Kanauj after a total course of about 370 miles. All through its course it receives small as well as a few large tributaries.

The Ramganga changed its course in the middle of the Nineteenth Century so that it flowed in the Dojora and passed the city of Bareilly. During the floods of 1871 it returned to its former course about 10 miles away but has once again approached the city. During the Floods its meanders are constantly shifting, sometimes carving out completely new channels and destroying much good land by covering it with sand. It is rarely used for irrigation. For navigation it has never been a safe river.

Gumti:- The Gumti rises in latitude $28^{\circ}35'$ N., and longitude/

longitude 80° 7' E. For the first twelve miles the river bed is shallow depression and dries up during the summer months. After receiving a couple of minor streams it takes a permanent course and never dries up. During its course of about 465 miles the river flows very sluggishly and windingly. In the earlier parts, that is, while it flows through the districts of Shahjahanpur and Kheri the river is a network of small channels, the flow of which is considerably choked by a thick growth of weeds and other aquatic plants. But when the river emerges from these districts it takes a straight and well-defined course till it reaches Lucknow. For these 180 miles the Gumti forms a well-defined single channel, its width increasing to between 100 to 200 feet within the high banks, which at places are as high as 50 feet, as for example near Lucknow.

After Lucknow the river resumes its winding character and takes such a circuitous path that in the distance between Jaunpur and Lucknow the river course is twice the straight distance between these two towns. Although the river is winding here, it is no longer a cluster of channels but a wide and deep river. The amount of water by this time is increased since many other small streams, e.g. Kathna and Sarayan flow into it. The width of the river which was 120 to 200 feet at Lucknow becomes 200 to 400 feet near Barabanki and swells up to 400 to 600 feet in Jaunpur. Here a large river known by the name of Sai, which has been running almost parallel to the Gumti for about 350 miles joins it. After another 70 miles it joins the Ganges in Gazipur district after a total course of about 500 miles.

The/

The catchment area of the Gumti is very extensive, being nearly 7500 square miles and with its many tributaries it is especially liable to floods, which cause great damage. It is said that in the year 1774 there was excessive flooding and the Gumti rose so high that it flowed over the bridge at Jaunpur. However the flood of 1894 during which the river rose to a height of 22 feet above the ordinary low water level attracted much attention. A careful survey was made and it was found that the cause of the floods was not spills from other rivers but excessive rains in the wide catchment area. The fall in the river is very little, being 9" per mile at Lucknow and only 6" per mile at Jaunpur, so that the flood water cannot be carried away quickly.

Jumna:- The Jumna takes its rise in Tehri State in latitude $31^{\circ}1'$ N. and longitude $78^{\circ}27'$ E. about eight miles west of a lofty peak of the Himalayas at a height of 20,731 feet. It receives a few minor tributaries during the first 80 miles of its course. It then enters the valley of Dehradun running south-westwards for about 22 miles. It forms the boundary between the Punjab and the United Provinces until Aligarh. During this part of its course it receives many minor tributaries such as the Katha Nadi and the Hindan. At Faizabad in the district of Muzaffarnagar it gives off the western and the eastern Jumna canals. About 10 miles south of Delhi the Agra canal is taken off from this river. Beyond Aligarh it crosses the districts of Muttra and Agra and receives a minor tributary Utangan in the last mentioned district. The river bed in Agra and Etawah/

Etawah district is extremely tortuous and lies deep below the high banks, which are extensively ravined. Near the border of the Etawah district it receives the biggest of its right-bank tributaries, the Chambal from Rajputana. The river then forms the boundary between the trans-Jumna tract and Cawnpore, Fatehpur and Allahabad where it meets the Ganges. The total length of its course is about 860 miles, made longer by the winding nature of the stream, in the plains, being even more circuitous than the Ganges. It does not carry such a big volume of water as the latter. Even the amount of water needed to feed the canals is insufficient and for this reason the supply of water into the river is increased from the Ganges by means of the cut into the Hindan⁽¹⁾. Timber, stones and grain are carried down the river. The river also supplies drinking water to Agra and Allahabad.

Sarda:- The Sarda takes its rise in the North-east corner of Kumaun close to the Tibetan frontier. After a few miles of its course it unites with Ratiganja and serves as the border between Nepal and the Kumaun hills. About 100 miles from its source it receives a tributary known as Sarju, after which the name Kali is gradually lost and the river is known as Sarju or more commonly Sarda. The river now descends to the plains in a series of rapids. The Sarda during this stretch is a typical hill torrent with a steep rocky bottom and the river often divides into a number of lesser streams which re-unite a few miles below the rapids. Below this point the river marches for a/

(1) This suggestion was given by the ^{Indian} ~~Report~~ Irrigation Commission in 1901.-03.

a few miles with the border between Nepal and the United Provinces, then cuts its way through the plain country and receives on the right bank the Chauka river. This river takes its rise in the Tarai and may occupy an old bed of the Sarda itself, though nothing definite can be asserted. Throughout the Tarai the river has different names and receives numerous small tributaries, the courses of which are often from South to North so that probably these tributaries also occupy old beds of the main river. After a long meandering course it finally joins the Gogra.

Gogra:- The Gogra takes its rise in Tibet in latitude $30^{\circ}40'$ N., and longitude $80^{\circ}48'$. For some distance it flows through Nepal territory under the name of Karnali or Kauriala and enters this province as a boundary line between the Kheri and Bahraich districts of the Tarai. During its South-easterly course it receives one of the branches of the Sarda and the Sarju and turns eastwards serving as the boundary between the Gonda district on the north and Barabanki and Fyzabad districts in the south. Further east it receives the Rapti and the Little Gandak from the north but receives very little drainage from the south, since the valley of this river is considerably higher than that of the Gumti which lies south of it. The Gogra then passes through Azamgarh and Ghazipur districts and later forms the provincial boundary between the Ballia district of the United Provinces and Bihar. It also gives off a branch known as Choti Sarju in Azamgarh district which can be distinguished as the old bed/

bed of the river without any great stretch of imagination. It flows into the Ganges in latitude $25^{\circ} 44'$ N., and Longitude $84^{\circ} 42'$ E.

Large quantities of timber, grain and spices are carried down the river from Nepal and, before the introduction of the railways, was the sole line of communication between Bihar and the north-eastern districts of the province. Steamers ply even to-day between Ajodhya (District Fyzebad) and Patna competing with the railways, both for goods and passengers.

Rapti:- The Rapti has its source in the ranges of Nepal in latitude $27^{\circ} 49'$ N., and longitude $82^{\circ} 44'$ E. It flows at first in a southerly direction, then North-west and west and finally in the southerly direction when it crosses the Nepal border and enters British territory. The total length of its course is about 400 miles mostly in an ever-shifting channel between high banks. The river is in flood sometimes but very rarely does any appreciable damage. It receives numerous minor streams from the Tarai. The Bakhira lake in Basti and Lake Chilwa in Gorakhpur also drain into this river. An old bed of the river known as the Burhi Rapti brings in a good supply of water during the rainy season. A considerable amount of grain and timber is brought down from Nepal and is carried to the Ganges through Gogra. The trade has suffered considerably by the construction of the B.N.W. Railway.

Betwa:- The latter rises in Bhopal State in latitude $23^{\circ} 2'$ N., and longitude $77^{\circ} 6'$ E., and flows in a North-easterly direction/

direction, passing through Jhansi district and meeting the Jumna after a short course of 190 miles in the United Provinces. In its upper reaches it flows over the Vindhyan Sandstones and also on a bed of granite in Jhansi district. The river has been dammed to supply the Betwa Canal about fifteen miles from Jhansi. The Jamni and Dhasan are the two most important tributaries.

Ken:- This river rises on the north-western slopes of the Kaimur range in latitude $23^{\circ}54'$ N., and longitude $80^{\circ}10'$ E. After a course of about 100 miles in the United Provinces it joins the Jumna at about 230 miles from its source. It flows through a bed of pebbles and sand and has a deep and well defined valley.

ORIGIN:- Soil is a product resulting from the disintegration and decomposition of rocks and of plant and animal materials. If the factors operating on the formation of soils are mainly physical as in the arid regions, the soils will mainly resemble the parent rocks. If, in addition, the rock particles are subjected to chemical and leaching action of water, as is often the case in humid regions, the soils bear very little resemblance to the original rocks.

The rivers rising in the hills are charged especially during flood time with many fragments of rocks varying from very minute particles of dust to stones of considerable size which are usually being carried downwards. When the speed of the river is checked, large stones followed by gravels are deposited, so to say, the load of the river is lightened. The river now only contains sand, both of coarser and finer type, as well as, dust or fine silt. The deposition of these materials depend upon whether the speed of the river has been completely or only partly checked. The coarser sand usually is deposited in the upper course, the finer sands in the middle course and the dust or silt in the lower course of the river. Thus it can be ascertained that the sorting of fragments and their deposition roughly in order of size depends upon the sorting action of running water. Within the Khadar of the rivers of this province it may be noted that there are no stones or/

or pebbles but the water is only muddy since the speed of the water is not sufficient to carry a heavy load.

The distribution of good and bad soils depends entirely on chance since in one place good loam may be covered by ~~coarse~~ sand, while at another place an unproductive sand may be covered over by a deposit of fine silt, thus improving the soil.

What is happening in the Khadar in a small scale to-day, happened on the alluvium on a large scale when the whole of the alluvium was a Khadar, with rivers flowing over it, in ~~imperfectly~~ ^{imperfectly} defined and ever-shifting channels. Where the speed of the river was checked slightly, sand was deposited and they can be identified to-day by sandy ridges known locally as Bhur, where there were pools or back-waters there is the Usar or alkali infested land, and elsewhere is the vast expanse of cultivable alluvium. The deposits of clay over sand and sand over clay were similarly accidental as in the Khadar. Thus it is clear that the ~~rougher~~ ^{coarser} deposits should be near the foot-hills of the Himalayas and the ~~heavier~~ ^{finer} deposits further away. Though there is a certain amount of heavy soils near the foot-hills and sand towards the east of the province, still, in general, the heavy soil is fairly representative of the eastern part of the province being far removed from the point where the speed of the river was first checked and similarly the upper and middle Doab (Ganges-Jumna) is the area of light soils.

Ingredients of the soil:-/

Ingredients of the soil:-

Sand is the coarsest particle in the formation of alluvial soils. The chemical composition of sand is mainly silica. Silt or clay is composed of smaller particles, the latter being silicates of alumina, iron, potash, soda and other substances with aluminium silicate predominating.

Lime is found practically in all soils in the province in adequate quantities and it is very rarely that the ^{soils} suffer from lack calcium. The presence of lime is very important for successful cultivation because of its property of aggregating soil particles and thus affecting water supply and nitrifying bacteria.

Silica, alumina and lime form the main bulk of soil. Other substances such as potash, phosphoric acid, iron and sulphur are in very minute quantities which can only be detected by standard chemical analysis. Soda if more than one in one thousand parts of soil is injurious. Other important substances that are present in the soil are:-

1. Decaying organic matter.
2. Bacteria.
3. Water and air in the ^{pore} ~~space~~ spaces without which the renewal of soil fertility and therefore successful cultivation is not possible.

The province can be divided into the following type of main soils:-

(1) Himalayan Soils -

These soils are preponderatingly sandy. ~~which are~~
(capped on the tertiary and mesozoic rocks). They may be primary or drift soils.

(2) Sub-Himalayan Soils -

(a) Bhabar - A slope of gravel and shingle on the Himalayan foothills.

(b) Tarai - Marshy drift soils covered by tall grasses and jungles.

(3) Genetic alluvium -

(a) Bhangar - clay, loams and sands.

(b) Khadar - alluvial river valleys.

(4) Vindhyan Soil - Highly matured soils that have undergone repeated secondary modifications.

(5) Red Soil - It is the result of ~~Metamorphic~~ weathering of the ancient crystalline and metamorphic rocks.

(6) East Satpura Soil or Gondwana Soils - Immature soil of a less variety and less fertility, usually pale ^{in colour,} thin sandy and calarious.

(7) Black Soil - Fine grained dark coloured soils, rich in iron, lime, magnesia and alumina and poor in phosphorous nitrogen and organic matter.

Himalayan Soil.

This is a group of soils found on the tertiary and mesozoic rocks, preponderatingly sandy. The soil caps on Siwalik foothills are primary soils and are highly porous and devoid of humus. The ~~northward~~ slopes of the hillsides support thick forests, and in the broad valleys of the foothills the soils are of drift nature. In the middle Himalayas the soils are generally scanty. Above seven thousand feet the soils is a mixture of glacial, fluvial and rain wash soils, supporting thick forests of pines and evergreens.

Sub-Himalayan Soils.

They can be divided into the following:-

- (a) Bhabar - A sub-recent deposit of gravel and shingle along the foot of lesser Himalayas falling within the boundary of this province. It is characteristic of Nepal Himalayas.
- (b) Tarai - The above slopes are fringed at their southern margin by marshy malarious tracts, supporting a forest growth and tall grass. Forest grows on a lighter soil whereas grass prefers the heavier soils. These are known as Tarai soils. The soil is a very near approach to the ^{meadow} bog-soils of Europe

Gangetic Alluvium.

The Gangetic alluvium which mainly covers the province is bounded on the north by the Himalayas, on the West and south roughly by the R. Jumna and on the east stretches as far as Bengal. It extends south of the R. Jumna over a belt of varying width.

The primary differences in the composition of soil throughout the length and breadth of the region are not chemical but mechanical. Whether sand loam or clay all depends upon the size of particles; the bigger the particles the sandier the soils and similarly the smaller the particles the heavier the soils. The intermediate soil between the two extremes is the well known loam. The local differences in the soils may be attributed to the sifting action of water from which they were deposited.

From the chemical point of view the greater part of the alluvium contains a good supply of lime, potash and phosphoric acid. Nitrogen is deficient as compared with English soils ~~but~~ due to ^{the} hot climate where the bacterial changes are plentiful, ^{and} there are more reasons than one for believing that the process of nitrification is more rapid than in cooler climates so that, though small, the supply of nitrogen is always renewed.

The classification recognised by the cultivators is Bhur or Balua corresponding to the sandy soil, Dumat corresponding/

corresponding to loam and Matiar to clay. A light loam is also recognized known as Pilia or Pilot which prevails over a large part of the alluvium. The heaviest clay which is impervious to water is known as Usar and is abandoned as unfit for cultivation. It should, however, be made clear that the line of distinction between the different classes of alluvium, though not arbitrary is defective. It is impossible to differentiate clearly between lighter clays and heavier loams or lighter loams and firmer sands. Therefore, the classification of any particular field will vary according to the judgment of the observer. The very fact that soils classed as sand in a district predominating in clay are known as light loams in districts having light soil shows how defective is this classification. What is more important therefore is to remember that the classification may and does vary from district to district according to the predominance of sand or clay, though the scale of classification is the same for all observers. Subdivision of clay, loam and sand is often merely a matter of convenience.

Another point of importance is the line of demarkation which has to be drawn between a cultivable and a waste land. Waste lands again may be very light infertile soils or the heavy clays infested with alkalis. To draw a line between the extremes presents us with insurmountable difficulties. It is only possible to do so on the spot and with great experience.

Before attempting to pass any judgment on the line of demarkation the following considerations have to be made:-

1. Density of population - where density is great inferior lands at the margin of profit will come under the plough.
2. Resources of cultivators - strong cattle will break those lands which could not possibly be tackled by weaker animals.
3. The prevailing price of the produce will also be a factor in determining the line of demarkation between the cultivable and waste land.

Another method of classification which is often followed by the cultivators is an improvement on the above classification. It is not purely a natural classification like the above system but in addition a due regard is paid to the amount of organic matter present or added. That is to say soil fertility is the basis of this classification.

Under the existing social conditions the fields adjoining the village site get the greater share of manures just because of their proximity to the cultivator's home and also because it is expensive to carry manure to distant fields. In the west of the province this classification breaks down as the cultivators of the west are usually accustomed to practice manuring in all their fields, whether near or far away, by turns, irrespective of position and so it is difficult to say whether the home land will yield more than the/



the outlying areas. This system of manuring of all the fields by turn as practiced in the west will not necessarily be more economical if adopted by the cultivators of the eastern part, since the western cultivator usually has a cart in which he can carry the manure to any distance without extra cost. Besides more manure is available to the western than to the eastern cultivator because of higher density and bigger size of cattle.

These points of economy in labour and availability of manure discussed here are in order to furnish a partial explanation of why the cultivator in the east should follow a different system of classification of soils from his western brother. Another important difference in this system of classification lies in the position of the cultivator's home. In the west the houses are aggregated into villages whereas in the east scattered houses and hamlets are more commonly found. The result is that the outlying fields in the west are far more distant than in the east and therefore the presence of such artificial system of classification renders a wider distribution of manures in the east than would be possible if the western system of aggregation of houses into villages prevailed in the east. The result of this system of classification in the east is that the fertility decreases with the distance from the village site or the group of houses. Paying crops such as wheat, rice, sugarcane etc., are grown on fields nearest the village sites.

The/

The point at which one class of soil passes into the other is again a very difficult problem. The remarks made above with regard to natural classification applies here with equal force if not more.

Usually the land is divided into the following:-

- (a) Gauhan - lands nearest to the village site.
- (b) Manjha - Middle zone between the above and the land lying farthest away.
- (c) Uparhar - The land farthest away from village site.

In some districts, however, the classification has been simplified by the omission of middle zone. The qualities of Gauhan or the homeland depend on the nature and size of mineral particles. An excessive amount of organic matter will, however, enable the soil to hold more water. Secondly, added organic matter results in extra bacterial activities which form nitrate in the soil so that the nitrogen content of the soil rapidly increases. Thirdly, manures applied to the soil return in an available form and recoup the losses sustained due to the previous crop. The distinguishing feature of Gauhan from Uparhar is the presence of nitrates in the former and lack of this in the latter. The fertility of the Gauhan land also depends on the location of houses. If they are built near the clay fields, the extra manure ~~will~~ further stiffens the soil/^{which} ~~and~~ may even sometimes obstruct the drainage but if the houses are built on the lighter soils, the benefit to such soils from extra manures is immense since the organic matter/

matter tends to improve and remedy the rapid loss of water which is the obvious object of such soils.

In some districts where a detailed classification of soils is practiced, account is taken of the natural classification as well, and a combined natural and artificial classification is set up and the soils are divided into Gauhan-Matiar, Gauhan-Dumat, Gauhan-Bhur etc. In other districts Gauhan is divided into two classes only, Gauhan-superior and Gauhan-inferior.

Lowland or Khadar alluvium.

These are generally found along the rivers and vary in extent from a few yards to the ten Mile Khadar of the Jumna in the middle Doab (Bulandshahr Dist) and equally extensive lowlands of the Gogra. All classes of natural soils from very loose sand to heavy clays are to be found in this tract, the only difference being their relatively small depth. Coarse and unproductive sand is always to be found a few inches below the surface of all natural soils and the productivity of the land is measured in inches of the surface clay or loam.

The chief characteristic of this region is its wetness since during the rainy season either it is a swamp or actually under water. During winter the surface seems dry, but ~~the~~ digging reveals water a few feet down. Kharif is sown as a speculation though it is seldom realized. Rabi is a safe crop as floods in winter are unknown, while the danger from drought is an impossibility in this region. The preparation/

preparation of soil is very difficult as the land remains wet till late. Only one or two ploughings are possible. In a dry season these lowlands are very productive but during the wet years they are very dangerous as the land is sometimes too wet for either ploughing or sowing, and if the crops are sown in such wet lands, they are liable to disease consequent upon the defective drainage.

If cultivation has been prevented for some reason or another, coarse grasses and shrubs come out which involve great expenditure to uproot before the cultivation of the next crop. Pigs and deer are sheltered in the shrub jungle and cause a great deal of damage to the Khadar crops. Residence in Khadar is disfavoured due to the Malarious climate, only a few low casts who are more or less immune to this disease stay there. Normally cultivators stay in the upland and come down to the Khadar during the sowing and harvesting time hence Gauhan land is almost unknown. Little or no manure is used and the land does not get that care which it would have had, had the cultivators lived there. Cultivation on this tract is scattered through stretches of barren sands and shrub jungles. The jungles are used as grazing areas for the neighbouring cattle and they are very helpful at the time of fodder famine and drought. Babul (*Acacia Arabica*) and April Flame or Dhak (*Butia Frondosa*) grow extensively in this region, the former mostly being used as fuel. A river terrace is noticed on the eastern bank of the Ganges little south of the/

the latitude of Delhi which is an intermediate zone between the Khadar proper and uplands. This part escapes flood but retains sufficient moisture for the successful Rabi cultivation and hence is densely populated because of fertility and security it affords. A succession of wet seasons result in the production of inferior crops.

Gangetic alluvium is by far the most important of the soil groups of the province as it contributes the largest share of agricultural wealth. It is a drift soil and entirely different in origin from other soils.

The Ganges and its tributaries have been responsible for the building up of this vast alluvium although a great deal of subordinate variation of soils exists in this vast tract. The streams deposit the products of weathering as they emerge into and traverse the plains.

The soils differ in consistency from drift sand to loam and from fine silts to stiff clays. The maximum thickness of the alluvial mantle is not known but at places borings over one thousand five hundred feet have not reached a rocky bottom. The presence of impervious clays partly obstructs drainage but helps in storing underground water under semi-artesian conditions. They also promote the accumulation of injurious salts like sodium and magnesium which render the soil sterile. The fertility of such an alluvial soil is not only determined by the variation of soil characters at the surface but also by the ease/

ease of drainage, physical consistency, retentivity and the moisture content &c.,

The soils generally contain an abundant supply of alkali and lime but their quantity is variable. In some places Kankars (nodules of concretionary lime) is found in fairly thick layers in some of the strata. Near the river valleys the soils is generally a rich loam yielding good crops under cultivation.

Trans-Jumna Soils.

The Bundelkhand soils i.e. the soils lying south of Jumna, differ widely from the soils discussed above. In the south of Banda and Hamirpur and a large part of Jhansi, the soil is not water-borne at all but consists of a few inches of drumbled rock soils.

Vindhyan Soil:-

The south-eastern portion of Banda, the southern part of Allahabad and the northern part of Mirzapur lie in the most northern plateau of Vindhya. Being an ancient formation the soils are highly matured having undergone repeated secondary modifications. Forest growths in the course of ages have altered the primary characters of these soils.

Quite an appreciable part of this formation is composed of limestone and calcarious rocks, which are slow soil formers. Pure limestones^a or dolomites^{thin} have very little of a soil cap.

Red Soil:- These are known as red soils due to their colour, the result of meteoric weathering of the ancient crystalline and metamorphic rocks. The thin layers of soil cannot hold water for a long time and thus a Rabi crop is not possible only the inferior millets being usually grown as Kharif crop. The land is too poor to stand a continuous cropping even once a year. Such soils have to be allowed to lie fallow after two or three years of successive cropping. Between patches of such soils or situated in the valleys between low hills is to be found a stable green cultivation carefully manured and watered from wells sunk in the solid rock, and worked by Persian-wheels with the help of a camel or a buffalo.

Last Satpura Soil or Gondwana:- Residual patches of Gondwana rocks occur in Mirzapur district among the crystalline rocks of the tableland. The Gondwana rocks are dissected to relatively steep slopes and so give rise to immature soil less in variety and in fertility than those of the plains. They are usually covered with thin forests, and are usually pale in colour, thin, sandy and calcareous, with neither salinity nor alkalinity. The dissection has converted considerable areas into "bad lands".

lack Soil:- To the north of the red soil country and also in the south of Jhansi water-borne deposits occur which are

quite distinct in character from the Gangetic alluvium. ^{They are} ~~It is~~ believed to have ^{their} ~~its~~ origin in the Central Indian highlands, and the area is known as black soil country. Four main types of such soils are recognised by the Bundala cultivator viz. Mar, Kabar, Parwa, and Rakar. They may be described as follows:-

Mar:- is a soft, fine, rich and friable black soil; when given the proper conditions it is a very good soil for the production of crops. If the rains have not been too deficient it produces a very good crop of wheat. However, if the rains have failed or are very scanty, it is difficult to work out this type of soil as it is too hard to plough and nothing can be done without a number of irrigations. This soil retains water for a long period. If there has been a heavy September rain there are often great difficulties in preparing the seed-bed in the soaked soil. Under such conditions peas and grams which are usually sown later do well.

Dark Soil or Kavar:- This is a dark soil, a shade lighter in colour than the above. It is very stiff and hence very difficult to work, ploughing being occasionally an impossibility due to the sticky condition when wet. After drying the soil cracks leaving wide gaps, tearing roots of the sown plants, and producing hard blocks. Rabi sowing is therefore very difficult and it is only sown if the rains have been normal. Usually Rabi is given up if the rains have been in considerable excess or defect. If the seed-bed has been prepared, it is possible to grow crops without irrigation.

Reddish/

Reddish Yellow Soil or Parwa:- This is a reddish or yellowish loam resembling the Pilot of the Gangetic alluvium in colour as well as in its behaviour towards water. It can successfully be irrigated if water is available, and this is necessary in the absence of good winter rains.

Inferior Black Soil or Rakar:- It is an inferior type of black soil and is highly denuded. Mar invariably lies on the level plains, and where the plains have been broken by rivers it passes into Kavar and this in turn passes into Rakar. Rakar soils bear very inferior crops.

Ravine Lands:- These are not cultivated land in the south but are a distinctive feature of the land to the south of the Jumna. Rakar usually passes into the ravine lands. When the pressure of population demands this type of land to be cultivated, afforestation and bunding or dyking to save scouring of water has to be taken recourse to before such land can be brought under cultivation.

All the above description is typical of the upland soils. Along the margin of streams there is a stretch of fertile alluvium known as Kachars or Tarai. These soils are always at the mercy of the rivers. Though they are not likely to ^{suffer} ~~suffer~~ from drought but the floods or extra humid conditions may ruin the crops altogether.

They are very fine grained dark coloured soils, the colour is due to richness and accumulation of humus. In the plains they are deeper and richer due to drift additions from the surrounding hills. On the slopes they are somewhat sandy. On/

On the uplands and slopes they are not so productive as in the plains. They do not require manuring for long periods but they are sensitive to water requirements. On drying they tear the ground along with the sown crop and leave wide gaps.

They are rich in iron, lime, magnesia and alumina but are poor in phosphorous nitrogen and organic matter. They usually have a bed of Kankar; a few feet below the surface formed by the segregation of calcium carbonate.

Schokalsky⁽¹⁾ differentiates between the two different types of drift soils, (Gangetic alluvium and black soil) where- as the three joint authors Wadia, Krishnan and Mukerjee⁽²⁾ have not differentiated between these two types of alluvial soils. Moreland⁽³⁾ has also made a differentiation between the above two soils.

(1) Schokalsky, Z.J. - The Natural conditions of soil formations in India - Contributions to the knowledge of the soils of Asia. 2. - attached soil map.

(2) Wadia, D.N., - Krishnan, M.S., and Mukerjee, P.N., - Introductory note on the Geological foundations of the soils of India - Agriculture and Live Stock in India - Jan. 1936. pp. 70 - 98.

(3) Moreland - The agriculture of the United Provinces. pp. 169 - 175.

Mechanical analysis of different Soils in the
United Provinces. (at Govt. farms).

<u>Agra Soils.</u>		<u>Group I.</u>			
<u>Name of soil</u> <u>or farm.</u>	Percentage of Clay	Percentage of fine Silt.	Percentage of silt.	Percentage of fine sand.	Percentage of coarse Sand.
Etawah Farm (Dt. Etawah)	1.6	18.04	17.13	48.61	0.265
Kalayanpur Farm (Dt. CAWNPORE)	12.08	10.15	21.00	53.58	1.88
Raya Farm (Dt. MUTTRA)	19.53	9.17	13.78	54.00	1.4
Kalai Farm (Dt. ALIGARH)	12.33	6.57	17.63	60.96	0.76
Government Research Farm, Cawnpore	15.19	13.13	21.24	44.07	1.88

<u>Udth Soils.</u>		<u>Group II.</u>			
Bahraich Farm (Dt. BAHRAICH)	7.7	6.43	19.55	44.2	13.28
Fyzabad Farm (Dt. FYZABAD)	10.43	11.07	26.73	47.33	1.59
Tulsipur Farm (District Gonda)	21.5	42.19	24.57	6.22	0.63
Suhratganj Farm (District Basti)	26.0	29.74	17.47	15.98	7.32
Katyar Estate Farm (District Hardoi)	13.57	15.91	22.26	41.59	0.40

<u>Bundelkhand Soils.</u>		<u>Group III.</u>			
Red	29.0	Nil.	17.7	16.7	36.6
Kawar	28.7	Nil.	36.7	33.6	1.0
Rakar	9.6	Nil.	32.2	56.3	1.8
Parwa	24.0	Nil.	32.0	35.0	9.0
Mar	18.0	Nil.	52.1	29.0	0.9

N.B. Figures kindly supplied by the Government Agricultural College,
Cawnpore.

A glance at the analysis of the above soils will reveal that in the Group I Kalai Farm soil is the sandiest having about 62% of fine and coarse sand, and that of Government Research farm Cawnpore has the least amount of sand (being about 46% of both types of sand). The former soil is a sandy loam situated in the middle Doab of the Ganges-Jumna and the latter is a firm loam situated in lower Doab of the same rivers. Ganges has been responsible for a deposition of the above soils (Cawnpore being 200 miles away from the first-named farm has a heavier soil).

Similarly in the Group II Fyzabad Farm and Katyar Estate Farm soils are the sandiest. The former is situated not far away from the Gogra river Bhur (sandy ridges) and the latter is only about 150 miles from the foothills of the Himalayas. In both cases the soil is a good loam and produces good crops. Tulsipur and Suhratganj both are situated in the Trans-Gogra tract and have heavy soils with very little sand. They are the typical heavy soils characteristic of trans-Gogra region.

In Group III, Mar, Kavar, Parwa and Rakar - the black soils of Bundelkhand - are typically in descending order from clay, heavy loam, light loam, finally to sandy soil as discussed in the last pages. The Red soils is an intermediate soil in composition, between the Parwa and Rakar but the thin capping does not allow of a successful agriculture due to its inability to hold water for long.

These soils it is expected will give some idea of the type of soils met with in the province.

A STUDY OF THE SOILS
OF A FEW REPRESENTATIVE DISTRICTS
OF THE GANGETIC PLAIN.

It was the writer's original intention to make a complete soil map of the Gangetic plain of the U.P., but due to unsurmountable difficulties he had to give up the idea and had to be content with only a detailed study of the soils in a few representative districts of the west, centre and eastern plain.

A study of the settlement reports of the different districts of the Province suggested to the writer that a complete map would be possible but it was discovered that different workers in different districts had their own ways of compiling a settlement map and there was thus no accurate way of deducing the soil divisions. Besides some of the settlement workers had not compiled any settlement maps from which it was intended to deduce the soil after a due consideration of the rental value of the land. However, an attempt has been made to study the soil on the basis of physiography, irrigation and rental value. Wherever the rental value of land has increased due to irrigation or has gone down due to erosion, allowance has been made. Muzaffarnagar and Budaun have been taken as the representatives of the western Gangetic plain or the wheat lands, Hardoi, Unao, Lucknow and Raebareli of the central area, and Gorakhpur and Basti as

that of the trans-Gogra tract of the eastern Gangetic plain.

Muzaffarnagar:- The first soil division is that of the Ganges ^{Good plain} (lowlands) which extends from the river to the sandy ridge of the high bank. Here the crops grow without irrigation and agriculture reaches a fair standard. In this tract tillage is easy and manure unnecessary ^{for grain} though the sandy soils require a good deal of manure to raise a Zaid (crops like melons, water melons and cucumbers). A lighter rainfall than normal does not injure the crops but a heavier one causes distress among the cultivators. ^{by} Lands lying nearer the river are higher in level (see Section I & II) and hence are not damaged by mild floods and these therefore are the parts which have a stable cultivation of crops like sugarcane and wheat.

The second division is the sandy tract lying between the high bank of the Ganges and the Kali-nadi. The chief feature of this tract is the sandy nature of the soil due to the nearness of the high sandy bank of the Ganges. Though there are patches where the soil is a firm loam (a part of nearly every village has these good soils if canal irrigated, still the whole tract has definitely soils of a sandy nature. The tract has been improved by canal irrigation. Manure is a necessity in order to bind the loose particles of sand and it is the homeland (or Gauhan) soils of the village that have become loamy in composition because of manure and irrigation.

The third tract includes the whole region from the Kali to the Katha. It is watered by the Ganges and the eastern Jumna canal, and is the region of highest fertility of the district. The soil throughout is mostly a firm loam tending to lightness towards the north, with the level plain broken only by the drainage lines of the Hindan and Krishna. The bottom of the drainage channels has a certain amount of alluvial soils and a little further away are the sandy pieces (As one approaches a river the soils tend to become sandy and as one goes farther away from them they become firmer). On the whole the soil of the tract is a firm loam with patches of lighter soils in the north and near the drainage lines. The tract grows all the important crops of the district.

The last division is the lowland tract of the Jumna and Katha, ranging in width from about 12 miles in the north to nearly nothing in the south. The fall in the level to the Jumna lowlands is not so abrupt as in the case of the lowlands of the Ganges, but the conditions in both the lowlands are widely different. There is no permanent swamp here, as in the Ganges lowland, the Jumna being a smaller stream, so that the natural moisture is not enough to dispense irrigation as in the lowlands of the Ganges, though the water level is high enough and has actually caused a greater spread of alkali. The out-turn and the rent rates are not

so different as the conditions of agriculture, as both are ever in danger of floods.

Budaun:- The district lies within the Ganges - Ramganga Doab and has extensive Ganges Khadir though the Ramganga has only a small Khadir. The district is representative of the districts of the western Gangetic plain east of the Ganges.

The Ganges flows through the entire length of the district in a northwest - southeast direction. It can be divided into four soil divisions:-

1. Ganges and Ramganga Lowlands:- The extent of the Ganges Khadir is measured from the Ganges to its high sandy bank and varies from about 12 miles in the northwest to about 2 or 3 miles in the southeast. Where the river has taken a southerly direction, the width of the Khadir has increased to about 6 miles. It is in the extreme southeast tract that an upper or higher Khadir is noticeable which escapes the frequent floods, a cause of distress to the cultivators of the lower Khadir. It yields very good crops of wheat, sugarcane and maize. The silt in the lower Khadir varies from a foot to two feet deep on the river sand and the fertility is naturally measured in terms of the depth of the upper layer of silt. The region produces lighter crops. Ordinary percolation wells are common throughout the lower Khadir tract and droughts are not widespread.

The danger in this area is always flooding and scouring.

The Ramganga Khadir is similar to the Ganges Khadir in all essentials except that the soil is not so sandy and hence is more fertile. The absence of a sandy strip after crossing the lowlands is also thus explained.

2. Bhur or Sandy Tract:- This is the region lying east of the Ganges lowland and runs parallel to it throughout the whole length of the district varying from 1 to 4 miles in width. Stray hamlets near the hollows having some silt or loam, are seen. On the whole this is the poorest tract. Wells are impossible due to sandy nature of the soil. Homelands are the only ones suitable for crops and the rest of the lands are at the mercy of the weather. Their soil and lack of irrigation are the two great drawbacks of the tract. Rolling sands and wind-swept areas are noticeable everywhere.

3. Dumat or Loam:- It occupies the north, centre and most of the east of the district and is by far the biggest soil division. The soil is a soft, friable and well-aerated loam producing good crops. Water-logging and ravining is rarely to be found and the tract is mostly uniform. Sandy outcrops from village to village persists but they are of a superior type. The success of agriculture and the intensity depends on the possibility of building earthen wells, though a large area is tilled without

the aid of wells. Repeated ploughings for the conservation of the sub-soil water in case of a normal rainfall is the most important problem for the cultivators of this tract, although more than half the area is protected by wells against adverse weather.

4. Matiyar or Clay:- East of the above tract lies the clay region running in a trough full of jhils (depressions filled with water) and heavily covered with alkali patches due to poor drainage. The only good soil producing a fine Rabi and sugarcane is found just adjacent to the Dumat tract where the loam washed down from the above overlies the moist heavy soil below.

Unao:- The district is ^{to} the north of Cawnpore and the Ganges acts as the boundary with Cawnpore. It is a district representative of the transitional zone of the Ganges plain. It can be divided into 3 important soil divisions as below:-

The Ganges Khadir:- In extent it is from about a mile to 6 or 8 miles broad. The river and its high bank form the boundary of this tract. Three types of Khadirs can be distinguished depending upon the flood level. The lowest one is always liable to fluvial action and flooding; above this is a belt more free from fluvial action but occasionally liable to serious floods. Still higher up is the superior Tarai which escapes severe floods though liable to mild flooding in very wet years. This is better populated and better cultivated than the rest.

Light Soiled Tract:- Three prominent regions of light soiled tract are distinguished (a) the light soiled country through which the river Sai flows (b) the country through which the Basaha flows and (c) a tract of country just above the Ganges Khadir, where at two places the light soil deteriorates to Bhur. Generally speaking, throughout the Province we come across lighter soils as we approach a stream.

Stiff Soiled Tracts:- These are found with a large preponderance of excellent and well irrigated Dumat interspersed with rice depressions. Wherever the soil is effected with superabundance of jhils and consequently bad drainage, it has turned into alkali of a poor quality producing scrubs or nothing at all. A group of 3 towns in the northwest has given rise to a town circle due to the availability of manure. These light soils in the Sai tract near the towns have been converted into good heavy soils because of suburban conditions and application of town manure.

Rae Bareli:- The Ganges and its affluents have carved out a distinct trough varying from 1 - 5 miles in width. The Sai crosses the district through the middle and runs parallel to the Ganges and has made for itself a tract of light soil on either side of it. The Naiya Nadi similarly passes through a tract of light soil. A fairly good loamy

tract having a direct drainage into the Ganges or one of its tributaries is distinguished. A tract of heavy soil to the north of the Sai in a depression alternating with sandy soils south of the Sai are all important soil features of the district.

Khadir of the Ganges:- It extends from the river to its high bank, and contains a strip of permanent cultivation, always giving a good Rabi without irrigation and often a Kharif. It is valuable and fetches a high rent. The soil is usually clayey and fertile where high enough to admit of sufficient cultivation. Where low-lying the crops are poor.

Southern Tract of Imperfect Drainage:- It is characterized by broad shallow jhils and with tortuous and meandering lakes which can be traced throughout the whole length of the district. This is the old bed of the Ganges. This theory may further be supported by the fact that the soils on the bank of these lakes are mostly sandy and nowhere stiffer than light loam. Bad drainage has caused alkali patches where the soil is heavy and does not afford easy percolation.

Loam Tract:- This is the tract having a direct drainage into the Ganges or the Sai, a patch of which lies in the N.E. of the above tract and another one is in the N.W. draining to the Sai. It consists of a light reddish loam

and grows crops of value, e.g. wheat and sugarcane. The tract is cut up by a number of Nalas or drainage lines. The Doabs between the Nalas are fertile but the soils on the edge of the Nalas tend to become sandy and often are pure sand.

Sai Zone (including Naiya Zone):- This is a tract of light soil on either side of the rivers varying from 4 to about 10 miles in width. It is at its best on the N.W. side 10 miles after Sai has entered the district. The river crosses the district throughout its entire length and runs in a tortuous course in a deep bed. The soil on both the banks is a light Dumat and is cut up by numerous tributaries to form Doabs of Dumat which are very fertile like the loam tract. The soils on the edge are pure sand again. The sandy tract of the Sai is far inferior to that of the Ganges and nothing can be grown without irrigation.

Heavy Soil North of the Sai Zone:- The rest of the district is situated within a plain of firm Dumat alternating with stiff clay. This is the tract of innumerable shallow depressions with extensive Usar plains and is the rice land of the district. Light soils are the exception and are rarely found in the villages. The soil is lighter towards the streams and stiffer away from the drainage lines being stiffest of all near the jhils.

Hardoi:- This is the district adjacent to Lucknow

towards the northwest. The Ganges, Ramganga, Senda and Garra rivers form an extensive lowland in the western quarter of the district separated by a sandy ridge from the eastern part of the district and by an upland plain broken only by the Sai. The district can therefore be divided into (a) lowlands (b) uplands.

Lowlands:- The Tarai forms the river valleys of the above 4 rivers and is separated from the upland by a sandy ridge. It is a tract of dissection and deposition as is usually the case in the river valleys. Just below the sandy ridge the Tarai is water-logged and scattered with alkali patches. By far the best soil is found on either side of Ramganga where the deposition work of the river is greatly in excess of erosion. The rich silt deposit improves the soil to medium alluvial Dumat and renders manuring unnecessary. Some of the best lowland villages of the Province are to be found in the Tarai of the Ramganga and the Garra. The Ganges lowland just south of the Ramganga has an inferior soil as the deposition of silt by the Ganges is counteracted by the predominating sand. The Garra is flanked on either side by a belt of rich fertile soil. The area traversed by the Senda ^(? = lower Ramganga?) is a tract of stiff clay suffering from water-logging at the time of flood. Besides, it is difficult to prepare the soil for Rabi without a good September rainfall. A Bhur tract in the extreme

northwest lying within the Doab of the Sarda and the Garra was a desolate-looking sandy tract and it was only after the advent of canal irrigation that the soil conditions improved. It is hoped ^{that,} with colonisation, ~~that~~ the tract will improve further.

Uplands:- The Hardoi branch of the Sarda canal passes through the most fertile tract of the district where the soil is a medium loam. To the east are the patches of low-lying depressions with Usar soils in the ill drained areas. Further east we find the drainage line of the Sai. The Sai basin has a light Dumat soil in its upper course; ⁱⁿ /the lower course sand begins to take the place of ~~the~~ loam. Sai Bhur (sand) is better than Gumti Bhur as the high sandy ridge is absent in this case. From the Hardoi branch of the Sarda canal the land slopes away eastwards into the basin of the Sai. East of the Sai the land slopes from north to south into an ill drained plain in Tahsil Sandila and the jhil and Usar tract north of it, on either side of which are the ideal Dumat soils. After crossing the Dumat soils we approach the tract of Gumti Bhur. The land improves the further one goes from the river. The chief feature of the Gumti Bhur is the predominance of the sandy ridge. This Bhur is unfertile and hardly ever any crops are grown. Nearer the big towns where plenty of manure is available market gardening becomes an important item for the cultivators of the

tract. The same order of the soils is noticed here as well -with the approaching river, the soil becomes lighter and finally sandy and away from it becomes stiffer and wherever the lands are low-lying gives rise to alkali patches.

Lucknow:- This district shows a diversity in physical characteristics. The Gumti is the main drainage line which passes through the centre of the district from N.W. to S.E. It is joined by 5 tributaries, all of which join the Gumti in the northern half of its course which as a consequence is better drained than the southern. The Sai forms a part of the southwestern border. Rivers are responsible for the variety of physical characters exhibited in this district.

Soils of Gumti Zone (Tarai, Bhur, and City Circles):- The whole valley of the Gumti including the Tarai and Bhur is the most precarious tract of the district, excessive rain being injurious to both the tracts equally. Kharif is liable to flooding in the Khadir but the stiff alluvium farther away from the river which is free from water-logging produces excellent wheat crops in normal years. Bhur has a low population and inferior cropping. Bajra and small millets predominate as irrigation is rare. Only in the town circle round about Lucknow has the Bhur been considerably improved by the application of manure and irrigation.

Population rises and masonry wells abound and hence better cropping results. The distance from the river improves considerably the quality of the soil, and with increase in the facilities for irrigation cropping is also improved as a ready market is always available. In the extreme northwest and the centre of the eastern end there are two large patches of Usar which do not grow good crops when heavily infected by Reh (Alkali). The soil round about the village site is excellent where not injured by Reh. Masonry wells abound in this area resulting in good cropping. Safeda melons are a speciality of the Usar tract. The eastern patch has the additional advantage of being near to the big market of Lucknow.

Soil of Behta Zone:- The Behta causes a certain amount of ravining along its banks and near its confluence with the Gumti, it does a considerable damage by scouring. Wherever not effected by ravines, the soil is a light loam of a fairly good quality and produces excellent crops.

Jhil Tract:- Abundance of low-lying depressions and Dhak forests (*Butea Frondosa*) cause a considerable damage in the agricultural pursuits of the northeastern part of the district. Wherever possible inferior paddy is grown.

Clay or Matiyar Tract:- The great southwestern tract has a heavy, stiffish loam soil alternating with rice depressions. The edges of these depressions are infested by

Reh due to the bad drainage of southern half of the tract as mentioned above. Mainly it is a rice-growing region but high water level permits the construction of non-masonry wells which fact secures a Rabi.

Soil of Sai Zone:- The southwest of the district has been influenced by this river. The soil tends to be light and in some places sand predominates. Irrigational facilities are scarce, hence the cropping is decidedly poor.

Dumat Tract:- This is also a soil influenced by the Gumti but as it is the best soil of the district, apart from the city circle, it requires separate treatment. A glance at the soil map of Lucknow will reveal three prominent patches of Dumat, a patch, in the east, a patch in the west and a patch in the southeast of the Gumti. These fertile loam belts form the Dumat tract. Distance from the river, and easier access to market coupled with effective drainage and facilities for irrigation have made the tract an important centre of intensive cultivation. Better and intensive cropping in turn has resulted in a rise of population.

Gorakhpur:- This does not include the whole district but only includes the important Tahsils of Padrauna, Hata and Deoria. The influence of the Gogra and the Gandak have been considerable in building the whole area. At first only two regions (a) Bangar or upland (b) Khadar or

lowland could be distinguished. Bhat soil may be merely a superimposed layer on the Bangar, being shallow on the higher grounds and deep in the hollows or troughs of the alluvium brought down by the Gandak and its tributaries. Three clear soil divisions can be found.

Bhat:- This tract also slopes, south or southeast towards the Gogra. The chief characteristic of this soil is that it is rich in carbonate of lime and hence retentive of moisture. Good crops can grow without irrigation. Cultivators are averse to irrigating Bhat because of the open nature of the soil. The soil needs a heavy dressing of manure and especially of phosphoric acid in which it is deficient. It is easier to work this soil than the Bangar. O'Byrne after some experiments came to the conclusion "that the same number of bullocks would plough 30 acres of Bhat as would plough 25 acres of Bangar; and that owing to its higher germinating powers the former requires 20 to 25 per cent less seed". (1). The changes of level in Bhat are never abrupt; the result is sloping undulations which can be correctly described as the rolling green fields sloping towards the Gogra. The influence of the Rapti and the Gandak have been great in building up this layer of soil now known as Bhat. The Chief crops are rice, wheat, barley,

(1) Final Report on the Revision of Settlement in the Gorakhpur district, United Provinces, 1919, p. 3.

peas and sugarcane.

Bangar:- This is the tract of medium stiff soil built up by the deposits of the ^{little Gogra} (Gogra and its affluents). It is in every way similar to the Gangetic alluvium but has not been built up by the Ganges. All types from fertile light loams to stiff clays can be found in this tract. The low-lying ones bear a crop of rice in the Kharif and peas in the Rabi. The uplands produce crops such as wheat and barley in the Rabi, and Kodon and Arhar in the winter. Wheat is not grown in lighter soils as a medium loam is the most suited for wheat.

KhadAr or the Lowlands of the Rapti, Gandak and Gogra:- In the extreme southwest is a tract flooded by the Rapti. It is fertile and well cultivated. Silt that is deposited during the floods is very productive and the evil effects of flooding are more than compensated by the deposition of fine of silt. The soil is retentive ~~and~~ moisture and therefore grows ~~grows~~ Rabi without irrigation.

Along the bank of the Gogra is a narrow strip of lowland country which grows barley in the rich silt. Mostly it is wooded. Cultivation often extends to the channel of the river as the slope to the Gogra is very gradual.

The Gandak lowlands for the most part grow late rice which is sown broadcast in April or May before the rains and is harvested in October, and rotated with blue peas. An

appreciable area is under forests of tamarisk and catechu. The tract is often flooded and the danger to agriculture is always from the floods.

Basti:- Here also the conditions are practically similar to the above tract. Bhat, Bangar and Tarai are the 3 important soil divisions as in the above. The conditions of agriculture are also identical, and hence the crops grown are the same.

It will be worth noting here that the influence of the Gandak does not predominate in this district to form the Bhat soil. It is the Rapti which has deposited the silt (rich in lime) to form this soil. Another point of importance is to note that the whole of the northern fringe of the district is occupied by late rice land. This is the portion which has recently been brought under the plough from within the Tarai forests. Swamps caused by bad drainage, stiff soil, and a heavy rainfall have all jointly contributed towards making it a tract of late rice.

Description of the land use map.

This map was prepared with a view to study general agriculture in greater details and correlating land use with land forms, soil and ultimately crop production. The map was constructed from a whole series of half inch maps numbering about two hundred and fifty sheets of the most recently available topographical maps of the Survey of India.⁽¹⁾

The map is particularly interesting as a basis to the study of problems relating to the use of land in agriculture. It also affords a very interesting study of the forests and uncultivable wastes due to alkalinity, sandy cliffs and ravines. Although unfortunately certain areas have not been covered (Latitude 24° to 25° N. and longitude 82° to $83^{\circ} 30'$ E; latitude $26^{\circ} 30'$ to 27° N. and longitude $79^{\circ} 30'$ E, and the extreme northern tracts in the Himalayan region) in this map due to the inability to procure such half inch maps as would have covered the above areas, still the greater and the most important part of the province has been covered.

A glance at the map clearly reveals the actual location of the areas under forest, under uncultivable waste and under/

(1) The compilation of this map was mainly due to the initiative of Dr. Arthur Geddes, Lecturer, Department of Geography, University of Edinburgh, who laid the compilation in the hands of his assistant, late Mr C. A. Stephen, M.A., who made a start on the method suggested by Dr. Geddes but was given up by him due to other pressing needs, when it came into the hands of the writer who completed the major portion of it.

under cultivation. The forests usually abound in the region of high rainfall, as a result of which the whole of the Montane tract is covered over by forests. The Tarai as well as few patches here and there, are also under forest. It is a pity that the Survey of India has made no attempts to distinguish the type of forests to enable a study on a more thorough basis, though in the latest edition of their maps the Survey of India has made some tree signs which has facilitated the writer's work on the deduction of soil groups to be discussed later. This has also helped the writer in solving some anomalies which was somewhat difficult to understand in the beginning. Taking an example it may be noted that quite an appreciable amount of land is under forests in the trans-Jumna region whereas the rainfall in this part is rather low (about 30 inches) not conducive to the growth of forests. Three signs, have, however, elucidated the fact that these are not the typical luxurious growth of forests that need a heavy rainfall but are the stunted growths of thorny bushes typically of xerophytic nature, with deep penetrating roots sucking their food material from greater depths. Nearness of these forest patches to the streams is also of interest to understand the existing forest vegetation.

The same holds true for the wastes. All kinds of wastes, whether cultivable or uncultivable have been included under this head. Here again the minor details are missing and/

and always involves a risk of wrong interpretation, but the knowledge of the country helped the writer in interpreting correctly. In the Ganges-Jumna Doab, for example, and also in the eastern Oudh, or the middle part of the Ganges-Gogra Doab, the Survey of India maps do not indicate anything beyond mapping the wastes. The writer's agricultural knowledge of both the regions show that the waste in the former region is mostly due to capillary action, as well as seepage due to canals whereas in the latter region it is due mostly to the predominance of heavy soils, bad drainage and sometimes due to a bed of secondary alluvium a few feet below. This bed of secondary alluvium (presence of Kankar or nodules of concretionary lime) sometimes completely stops the drainage and renders the land unfit for cultivation due to the excessive alkali deposits. Similarly we are left in the dark regarding the causes of the existing wastes in trans-Jumna tract. It is, however, not due to any defects in the soil but due to the rocky nature of the tract and consequently pronounced gullying near the main streams and their tributaries.

The arable land has again not been divided into groups e.g. (a) predominating in sand (b) predominating in clay, and (c) the loams, and they have all been grouped under one head of cultivable land. The greater part of the Khadar the hilly slopes of Bundelkhand or the trans-Jumna tract and

a part of the forested region of the Himalayas and also a greater part of the Tarai are under grazing but nothing definite has been shown in the half inch maps to distinguish grazing from the cultivated land. Any attempt at a definite boundary between the cultivated and grazing lands or the grazing and forested lands will almost be an impossible task. But a study of the soils on the basis of sand clay and loams has been done which has been thoroughly discussed on the chapter on soils of the province. For this study the land use map, the contour map and settlement reports have been of tremendous help.

Soil groups as deduced from the
Settlement Reports.

An attempt has been made to correlate the soils of the United Provinces with land forms/ ^{and land use.} The contours have been drawn at an interval of fifty feet with the help of spot heights given in the one inch, half inch or quarter inch maps, including canal banks and railway ground level. The latter being kindly supplied to Dr. Geddes by some of the railway companies of India. At the outset it was a somewhat laborious job to jot down the heights to scale, to study the maps and finally to draw the contours, but after a few days the work was smoothed down. The knowledge of the country has been a great asset to the writer in carrying on the task of mapping correlation between the land forms, the soil and the land use.

Work on this line proceeded with impediment due to lack of data and apparent ease of correlation, but thanks to the supervisor who went through quite a lot of the Survey of India sheets together with the writer; ~~and~~ the joint effort showed signs of fruit. The work was resumed with vigour due to strong promise the map showed of correlation of the contours with the soil.

A preliminary comparison of contours, land use boundaries, and soils for the districts in which the soils were mapped showed (a) the close correspondence of forms with soil- of ridges with sand and of hollows with clays, and (b) further showed/

showed the causal relationship of these with land use - forests corresponded with heavy soils and wastes with light soils.

Wastes can be of many types - due to over-drainage and gullyng or to water logging and salinity, but the distinction is not always self-evident in the topographical maps. Close study of forms, soils and wastes suggested that the differentiation of various types ^{of soils} could be hazarded.

Hence it seemed clear that even where distinct soil maps were lacking it should be possible to work back from the correlation of forms (contours) with land use (wastes &c.) to localisation with reasonable certainty ^{as to} ~~upon~~ the soil characters.

The two categories

Care has been taken to differentiate ^{on} the soil map and in any conclusions derived therefrom. (Those tracts in which the soil map ^{is derived} ~~was derived from Settlement reports and those~~ ^{for} ~~in~~ which the soil distribution was mapped by inference).

It should be noted that causally the forms and soils induce the land use and to complete the map of soils (for which data is lacking) we had to argue backwards as it were from effect to cause.

Time being short at the writer's disposal, soil groups have been only tentatively established in a part of the province and not the whole. It is a pity that the writer is/

is not able to submit a complete soil grouping for the whole of the province but however a method is being advocated on which a regular soil map can be built up with a fair amount of accuracy.

Soil informations for the eight districts for which a description has already been given had been transferred on the soil map. The land form and land use were studied in the light of the above soil informations. The correlations were noted which helped as a guide for plotting the rest of the soils. The results were checked by the topographical maps and finally reduced on the scale. Where there were mixture of soils to such a big extent that one clear cut group was not possible, two signs have been made to show the two types of soils.

One or two minor changes have been made in the original soil groups reduced from the settlement reports which was thought justifiable on the basis of a critical study of the soils. In the district of Budaun (latitude 28°N.) the Khadar was extended in the original, which has been reduced. An intermediate zone of loam was noticed between the clay belt and the sandy belt of Sai between the latitudes of 26°N and 27°N , which has also been shown in this map.

General description of the soil groupings mapped by inference:-

Latitude $28^{\circ} 30' \text{ N.}$ to $29^{\circ} 30' \text{ N.}$:-

The Khadar varies in breadth from 1 to 4 miles. In the northern/

northern half the sandy belt is about 8 miles broad and in the southern half it diminishes to about 3 or 4 miles. The rest of the soil between this sandy belt and the Ramganga is composed of a fairly productive loam. The minor streams within the belt of loam have a very narrow Khadar. These streams give rise to local soils changing the loam to sand here and there. After the Ramganga Khadar we come across again a loam soil which in the north becomes of a lighter nature with a mixture of sand.

Latitude 27° 30' N. to 28°N:-

The land between the Ganges and Ramganga is mostly of Khadar type of soil with a tongue of loam passing between the two rivers. To the east of the Ramganga lowlands for about 10 miles the soil is a mixture of sand and loam where the upland is broken by the Khadar of a small stream and further east the soil stiffens to a typical loam with particles of clay to the extreme east. Only the soil deteriorates to sand when a minor stream cuts through the loam.

Latitude 26° N. to 27°N.:-

The land between Gumti and Sai is a mixture of clay and loam which becomes sandy as we approach any of the rivers. The central tract is mostly clay with a mixture of clay and loam on either side of it. To the east of Gumti lies a tract of loam about 5 miles broad which stiffens to a mixture of loam and clay becoming predominantly loam as it approaches the/

the extensive Gogra Khadar. The Gumti and the Sai rivers have both a negligible Khadar but a fairish amount of sand on either side, probably because of their origin from the Bhangar or the upland plain.

The land between Basti and the eastern half of Gorakhpur districts is mostly covered by a fairly good type of loam and light clay with a high percentage of lime because the rivers after emerging from the hills pass through a series of lime stone ridges. In the extreme north is to be found a patch of heavy clay soil of a marshy nature. Probably this was under grass before the land was reclaimed from the Tarai. River Khadars within the whole of this area is not very extensive.

C L I M A T E .

CHAPTER IV.

It is a well known fact that the climate of a place is determined by the ~~situation~~ ^{altitude and situation is.} latitude ~~and~~ nearness or distance to the ~~mountain~~ sea, and in this case also to the mountains.

The country under the present inquiry has an inland situation removed far away from the sea. It has formidable mountain barriers on the north. It must not be forgotten that the United Provinces is not a separate ^{climatic unit,} ~~meteorological entity,~~ and therefore the climatic conditions depend very largely upon the oceanic area of the South West and the South East and the mighty Himalayan ^{system} ~~chain~~ on the North.

The Province lies entirely within the temperate zone but due to the presence of the mighty mountain ranges on the north it falls into the tropical monsoon type of climate (1). These mountain ranges are a complete barrier to the climatic conditions to the north and south of it (2).

"In one season of the year India is the scene of a most wonderful and rapid growth of vegetation, in another period the

(1) L. W. Lyde: The Continent of Asia, p. 357.

(2) D. N. Wadia: Geology of India, p. 8.

same tract becomes a dreary, brown sun burnt waste with dust laden sky and a heated atmosphere that is almost unbearable even by the natives of the country. The transition from the latter to the former phase over the greater part of the interior often occurs in a few days. In one year the rains may be so distributed as to cause a severe and extensive famine over several provinces, in another the meteorological conditions may be so favourable that the crops far more than suffice for the normal food demand"(1).

The following division of the year is made by the meteorological department and is also favourable for the purposes of the present inquiry because the divisions suit the agricultural conditions of the Province:-(2)

1. THE SEASON OF THE NORTH EAST MONSOON.

(a) Cold weather season - January to February.

January is undoubtedly the ^{coolest} ~~coldest~~ month of the year. The days are marked by moderate temperature but the nights are unquestionably cold, and sometimes the temperature falls below freezing point. Hoar-frost, though not of common occurrence, still is not rare. The mean temperature in the month of January varies between 55°F. and 64°F. The mean minimum is between 43°F. and 51°F. and the mean maximum is between 66°F. and 77°F.

(1) I. G. of India, Vol. I. 1908, p. 105.

(2) July is not the hottest month of the year but July temperature is more important as the crop is growing at the field at that time. Kharif crop is not sown during May or JUNE - the hottest months of the year.

CLIMATE

NORMAL MAX. NORMAL MIN. & MEAN IN JAN. & FEB.

	January			February		
	Max.	Min.	Mean	Max.	Min.	Mean
Gorakhpur	72.8	48.7	60.8	77.4	52.1	64.8
Benares	74.3	47.9	61.1	79.5	51.8	65.7
Allahabad	74.4	48.0	61.2	79.5	51.9	65.7
Cawnpore	73.8	47.2	60.5	78.4	51.1	64.8
Lucknow	73.7	47.0	60.4	78.4	51.0	64.7
Bahraich	72.5	47.4	59.9	76.4	50.5	63.5
Jhansi	76.1	50.9	63.5	80.8	55.1	67.9
Agra	74.2	43.8	59.2	78.5	46.9	62.7
Mainpuri	72.4	46.6	59.4	76.9	49.8	63.4
Bareilly	70.3	46.2	58.3	75.2	49.7	62.4
Roorkle	68.8	43.9	56.4	72.7	47.2	59.9
Dehrdun	66.0	44.7	55.4	69.0	46.7	57.9

Figures Kindly Supplied
by the Metereological Office, Agra.

In February the temperature begins to rise. The mean becomes 57°F. to 66°F. the mean minimum being 46°F to 56°F. and the mean maximum being 67°F. to 81°F. The diurnal range of temperature is great during both the months.

It is believed that the winter temperature of the Province is between 3°F. and 5°F. above what it would have been were it not for the lofty range of the Himalayas on the north. They shelter the Gangetic plains against the adverse cold winds of the north which blow in China (1). Thus one can see that the Gangetic plains are completely protected from the piercing northern winds of Central Asia which at this time of the year become the seat of very high atmospheric pressure. "The north -

(1) I. G. of India, Vol. I. 1908, p. 107.

west winds of the plains of India must be regarded as local in origin, that is to say the downward settling of the air which feeds them must be going on over the north of India itself and not over the interior of Asia" (1).

The direction of the wind at this time of the year is northern, north-western or western; more in the direction of the rivers themselves than any other. The velocity of the wind is about 2 to 3 miles per hour and hence the absence of windmills; this fact has also been discussed by Blandford (2).

January and February are the most pleasant months of the year from the point of view of Europeans, the only difference being that the days have got a greater sunshine than the European winters. This fact naturally gives rise to a bigger diurnal range. The out blowing winds give very little rain fall and the sky is usually clear, consequently the humidity is low. *The peasants enjoy the winter, only the earlier part of the mornings are disliked because they are not sufficiently dressed.*

The rains during these months are usually received by land storms moving from the west to the east across the Iran plateau. They are supposed to have an upper humid current and they have nothing to do with the lower dry current. Their origin is still a matter of dispute. Blandford had come to the conclusion that

(1) W. G. Kendrew: Climate of the Continents, p. 97.

(2) H. F. Blandford: Climates and Weather of India, Ceylon and Burma, 1887, pp. 30 - 31.

these land storms originated in India itself (1). Sir John Elliot believes that they originated either in the Iran table-land or in the Syrian desert (2). None of these writers ever believed that ^{these} ~~than~~ disturbances were the continuation of the European disturbances. But a collection of data proves that seven out of every ten depressions are the continuation of the southern European disturbances (3). Nothing certain is yet known about the origin of these depressions and more data is being collected to establish a final correlation (4).

Usually the depressions travel from December to February in south of Persia, and they cause rain in the plains of the Punjab and the Ganges. March, April and May are the normal months for the passage of these depressions in northern Persia, due to northward shifting of the thermal equator and they give rain to the hills of the Punjab and the United Provinces till late in April and snow falls even in May (5). It has been observed that in years of less rain-fall these depressions take a more northerly course resulting in light rainfall in the

(1) M.I.M.D. Vol. IV, pt. VIII, pp. 828 - 829.

(2) I. G. of India, Vol. I. p. 113.

(3) M.I.M.D. Vol. XXI, pt. 7, pp. 4 - 5 .

(4) M.I.M.D. Vol. XXIV, pt. 2, Rainfall type in India in the cold weather period, pp. 350 - 353.

(5) M.I.M.D. Vol. XXI, pt. 7, pp. 4 - 5.

plains, occurring chiefly in the montane and sub-montane tracts. The course of these depressions vary from year to year but they have not been explained with any certainty. According to Kendrow "there seems to be a close connection between them and the depressions which appear in winter over the Mediterranean Sea, since the winter cyclones of North India occur in the same season in nearly the same latitude and also in the same direction" (1). Some depressions in the month of May have actually been traced out from the Mediterranean. The depression is caused at the Mediterranean, and travels eastward across Syria, Iran into India. They are shallow disturbances and usually are not accompanied by strong winds, they first pass over the Punjab, then travel eastwards as far as Bengal (2). These depressions sometimes cause light showers and sometimes heavy rains. The heaviest snow falls in the montane tract during this time of the year. After the advent of these depressions the weather becomes clear and the temperature begins to rise. Strong west winds begin to blow, so much so that the March winds are a nuisance to the agriculturists of India; The lodging of wheat is very common and sometimes fields after fields suffer from it.

The winter rains though not sufficient in quantity still

(1) W. G. Kendrow: Op. Cit. pp. 98 - 99.

(2) " " " " " " " "

are very useful from an economic point of view as the spring crops e.g. wheat, barley, are dependent absolutely on these rains. The crops would not mature without the aid of this rainfall. In case of a failure of these rains a disaster is caused, sometimes a milder type of famine may be caused. But undoubtedly this brings/ ^{about} a great distress among the cultivating classes of India.

The rainfall as noted above is small in the plains, it reaches the maximum in the hilly tracts of the Province. The rainfall decreases from northwest to southeast and from hills to the plains. Usually in the western part of the Province the winter rains are between 3 and 5 inches diminishing to about 1 inch in the east.

(b) Hot weather season - March to Mid June.

With the approach of March the temperature rises considerably due to the northward movement of the sun. The winds are stronger and dry. The sky is cloudless. The average temperature does not exceed 80°F. April and May are hotter still, 85°F. being the mean temperature for April and exceed 90°F. in May. Temperature over 105°F. is not unusual in the month of May. June temperature exceeds this limit and an average of 100°F. to 110°F. is usual, though 120°F. is not uncommon in some parts of the Gangetic plains, e.g. Agra, Jhansi, Aligarh, etc. May and June are of course the hottest months. The earlier part of March is not unpleasant but May and June are

unbearable even by the natives of the country.

The high temperature is accompanied by a continuous decrease of pressure and in the months of May and June, the winds become hot and westerly and also increase in velocity. Locally this scorching wind is known as 'loo'. At this time of the year Upper Sind, Western Punjab and Rajputana become a centre of low pressure. The sandy wastes and the river sands of Rajputana and Sind provide sufficient material for the dust storms which are frequent in the Province. Sometimes these storms are so heavily charged with dust that they convert the day into night and people have to switch on their lights before attempting to do any work. Wherever one goes nothing but dust is visible. Sometimes these dust storms are accompanied by hail storms due to wide diurnal range of temperature and the contrasts in humidity. These storms advance towards the east with a tremendous speed often uprooting big trees and causing damage to property and life. After some showers the dust subsides and it becomes pleasantly cool and affords relief from the scorching heat. These rains serve no useful purpose to the cultivating classes, rather injure the standing crops. Precipitation not exceeding 1 inch is normally received through the aid of these storms. The strong westerly winds cease to blow in the later part of June and a sort of calm prevails with a stuffy atmosphere all round. This is the period when there is no rain and it prepares the way for the bursting of ^{the} monsoon.

2. SEASON OF SOUTH WEST MONSOON.

(c) Season of general rains - Mid June to September.

By the middle of June a strong pressure gradient is established from the seas (Arabian Sea and Bay of Bengal) to the land. The result is that the sea winds begin to blow, carrying with them moisture. The direction of the winds is south-westerly, The Bay of Bengal current is deflected towards the west by the Arakan hills and the Arabian Sea current passes through Kathiawar north-eastwards and is deflected northwards having come in contact with the Aravali hills until it unites with the Bay of Bengal current and continues with it towards the Punjab. The rains derived from the Bay of Bengal Branch of the monsoon decrease from east to west throughout the Gangetic Plain, including the U.P., the south-western part of the province receiving the least Monsoon rain.

Before the bursting of the monsoons there is suddenly a great change in the atmosphere. The dry westerly wind increases in force and the sky becomes overcast presumably as the moist easterly current rises over it. A sudden heavy downpour of rain with flashes of lightning and violent thunder announces the approach of the rainy season, which is to prevail for the next few months.

The regularity and the amount of rainfall depends upon the predominance of the prevailing winds, south-west and eastern. The greater amount of rainfall is received from the Bay of

Bengal current/^{and} ~~the~~ the sudden and heavy downpours are caused by
^{rapid uprising.}
 the ~~union of the two currents from both directions. Between the~~
~~two currents is the trough of~~ low pressure/^{is formed} which "usually
 stretches from Sirsa through Agra, Allahabad and Hazaribagh on to
 Orissa. It is characterised by lower pressure and by prevalence
 of much more variable and unsteady but stronger winds than the
 areas immediately to north or south. A very marked tendency
 exists for cyclonic storms forming in the north of the Bay during
 the period to advance along this trough" (1).

This period is the real rainy season of the Province and
 about 88% of the total rain is received during this time, 20th
 June is the normal date for the bursting of monsoons in this
 province. In the eastern parts round about Gorakhpur and
 Benares the monsoon bursts about three days earlier than the west-
 ern part of the Province round about Meerut. The Province
 receives about 5 inches of rain in the month of June and about 11
 inches in the months of July and August each. September again
 gives only 5 inches of rain. The rains are characterised by
 breaks either short or long during which strong westerly winds
 prevail.

The Himalayas receive the greatest share of rainfall, the
 sub-montane tract comes next. The plains receive less than any
 of the above mentioned tracts. In the plains also eastern

(1) I. G. of India, Vol. I. p. 124.

districts receive more rainfall than the south-western as the currents become exhausted when they reach the south-western districts. The breaking of the monsoon is eagerly awaited by the cultivators as a delay or defect may cause a serious concern to them. Wherever irrigation is available the cultivators sow their crops with irrigation so that they may not have to depend upon the vagaries of the characteristic Indian rainfall.

During this season the temperature goes down by about 8°F. but the moist heat is unpleasant and trying. The diurnal range is small.

(d) ^{October} ~~September~~ to December - the season of the retreating monsoon.

The monsoon rains begin to stop by the end of September. The area of rainfall contracts towards the south and finally disappears through the Bay of Bengal. Sometimes a late fall occurs in October which is of great economic value for agriculture. This is known in the eastern districts as Hathiwa rains. Hathiwa makes the sowing of winter crops easier. No irrigation is needed for sowing if there has been a good Hathiwa rain.

Skies are usually clear and the damp winds are replaced by light dry westerly winds. Temperature rises for the first few

days finally to fall. From the middle of October the temperature starts decreasing. November is colder and practically rainless. December is one of the coldest months in the Province and a few light showers late in December is not an exception. Throughout the whole period from October to December there is a large diurnal range of temperature. The nights are colder due to clear skies and dry westerly winds but the day receives the full share of the heat of the sun due to the absence of clouds and hence the large diurnal range of temperature. The change from wet to dry monsoon is completed by December.

The Province receives about 3 inches of rain during this season most of which is concentrated in the latter part of September and October. November/^{as has been said before is}~~and December are~~ practically rainless and/^{is}~~are~~ characterised by clear skies. ^{The} few showers/^{that}~~are~~ fall in December/^{are}~~which are~~ of very great economic importance for the growing winter crops which by December have absorbed all water from the fields and stand greatly in need of water. If December has no showers, artificial irrigation has to be given, hence the importance of winter rains for the wheat crops of India.

This season from October to December is the most healthy and pleasant part of the year characterised by light dry westerly winds, clear skies and suitable temperature - neither too hot nor too cold.

~~Explanatory~~ Distribution of Rainfall in the Province

A summary of the distribution of rainfall studied from 1921-1935 clearly shows the following peculiarities of its own:-

1. The rainfall may be completely unevenly distributed within the Province giving more rains than average to one part and less than the average to the others.

2. Winter rains are quite uncertain in the plains region which is very important from an economic point of view as the future and extension of acreage under winter crops depends on the ^{certainty} ~~surety~~ of winter rains, in absence of which recourse to artificial irrigation has to be taken, thereby increasing the cost of production.

3. Sub-montane and eastern tract receive greater rainfall.

4. The south-eastern districts of the Province suffer most from ~~deficient~~ rainfall.

Normal Distribution of Rainfall in the Province.

Usually the rainy season starts by the last week of June and ends by the first week of October. July and August are the months of heaviest rainfall. Hathiwa rains in October in the eastern districts and snow and rainfall in December and January in the montane and sub-montane tracts respectively and light ^{are} showers in the plains ~~xx~~ normal.

(1) See A.V. Williamson & K.C.T. Clark: The Variability of the Annual Rainfall of India, Ind. R. Met. S. Vol. XVII, 1934, pp. 43-56.

Variation from the Normal Regime:-

1. The rains may start a few weeks late.
2. The cessation of rains may be earlier than usual.
3. There may be long breaks in the rainy season in the months of August and September when it is most needed.
4. The rains may be much above or below the average from year to year.

From an economic point of view the above conditions have the greatest bearing on the agriculture of the Province. With a normal regime cultivators are able to raise the desired crops whereas a deviation from the above regime may mean a disaster or famine. An excessive rain deteriorates the crop,^{as} the roots may suffer from water-logging. The crop may suffer from fungal diseases and so on. A deficient rain may cause the wholesale withering of the chief crops on which depends the prosperity of the cultivating classes. Either of these conditions have been and still to some extent are the chief causes of distress among the cultivators and once the equilibrium is upset, it becomes very hard for ^{them} ~~xxx~~ to recoup.

Climatic Regions:-

On the basis of the general discussion of climate given above the province of the United Provinces may be divided into the following regions:-

1. The Himalayan - ^{precipitation} ~~rainfall~~ in winter as well as in summer, ^{the former} ~~latter~~ mostly in the form of snow. Mean January

temperature below 55°F. and mean summer temperature does not exceed 85°F.

2. East Gangetic plains - heavy rainfall as the region receives the monsoon first but winter rainfall is scanty. Summer mean temperature is between 85°F. and 95°F. increasing towards the west. The winters are shorter and less rigorous than the western districts of the Gangetic plain.

3. West Gangetic plain - has a moderate rainfall. Very hot and dry in summer. Summer temperature is between 90°F. and 95°F. Winter temperature is between 55°F. and 65°F. Hot winds known as 'Loo' are severe. Summer Rainfall varies between 25 and 40 inches and the winter rainfall averages about 3 inches.

4. Trans-Jumna - this is very hot during early summer due to nearness to the Rajputana desert. Loo is extremely strong. Summer temperature varies between 95°F. and 100°F. The winters are also severe. Diurnal range in this ^{region} ~~range~~ is far greater than elsewhere. This is a region of poor rainfall only between 25 and 35 inches, thus is the driest part of the Province. It includes Bundelkhand and parts of the districts of Agra and Muttra.

N. B. See Williamson A. V. and Clark K. G. T. — Rainfall regions of India — Geography, June 1931. pp. 98-108.

96 a.

Correlation between variability and index of aridity:-

The map showing the variability of the annual rainfall of the United Provinces has been prepared on the basis of Williamson & Clark⁽¹⁾ and the one showing index of aridity is based upon De Martonne⁽²⁾.

They show the following correlations:-

1. ^{High} ~~Heavy~~ rainfall has the least variability. The whole of the Montane and the Sub-Montane tracts along with Benares and Gorakhpur Divisions have less than 20% variability. This, therefore, indicates that this region is not liable to suffer so much from the vicissitudes of rainfall. As a result, we notice a fairly high standard of agriculture supported by a very high density of population in the latter tracts (Benares and Gorakhpur divisions). The other operative factors have reduced the density of the Montane and the Sub-Montane tracts.

Index of aridity over the above area is over 25, showing thereby that it is not subject to a great extent to aridity, and therefore agriculture should be prosperous under normal conditions.

A direct correlation therefore is established that, ^{the} lower the variability the higher is the index of aridity.

2. The area of average rainfall (ranging between 30 and 40 inches) has a variability ranging between 20 and 26%. This tract includes most of the Gangetic plain. This is the area of higher variability as compared with the above region, hence more liable to suffer from the vicissitudes of rainfall, than the above tract.

- (1) Williamson, A.V., and Clark, K.G.T. - ~~Rainfall regions of India - Geography, June, 1931 - pp. 98-100.~~ *The Variability of the annual rainfall of India. Q. J. R. Met. S. - vol. LVII. 1931. pp. 43-53.*
- (2) Martonne, E. de., - Interior basin drainage - The Geographical Review, Vol. XVII, 1927. - p. 405.

About 30 stations were used for the construction of this map.

The density of population for the most part is above 500.

Index of aridity for the greater part is over 20, though a few districts of the Ganges-Jumna Doab is below 20. The tract is subject to aridity to a greater degree than the above tract. ~~The~~ Agriculture is successful if irrigation is resorted to in case of prevailing arid conditions.

The same correlation holds good. The variability is comparatively higher and the index of aridity consequently lower.

3. The land south and west of Jumna.

This is the land of very poor rainfall and has the biggest variability of rainfall. It varies from 22% to over 31%, the biggest variability of the province. Due to the variable nature of rainfall the tract is very poorly developed in agriculture. Though this tract is protected by canals, they are not sufficient to meet the demand of a failure of monsoons. Density consequently over the greater area is below 200.

The index of aridity is the lowest showing thereby the liability to arid and famine conditions. A study of famines during the past century will convince us of the above statement.

This is the land of highest variability and the least index of aridity.

The variability and the index of aridity are two important signs on the basis of which/^{necessary}~~important~~ agricultural improvements can be attained. When annual variability is high and index of aridity is low it indicates that unless irrigation facilities are provided to cope the vagaries of rainfall, the land will be the scene of disastrous famines within the near future. Although it can/

can produce bumper crop this year but ^{it} may be a pitiful sight of disaster and famine the next year.

The density of population is a very good indication by which the agricultural prosperity of a country can be measured, ~~in an agricultural country like India.~~

The following table will furnish us with some interesting study:-

Districts	Variability	Index of Aridity.	Rain-fall.	Density of population
Gorakhpur	15.8	Over 30	48.15	787.
Ballia	15.0	Between 25 and 30.	41.45	742.
Bareilly	24.1	Between 20 and 25.	44.48	679.
Cawnpore	23.7	do.	31.99	512.
Jhansi	25.2	do.	35.86	191.
Muttra	31.4	Below 20.	23.63	461.

In the above table we notice Gorakhpur having the highest index of aridity, has the biggest density of population. It is not the index alone which can account for its high density. The variability is also low. This shows that the district has a very little possibility of suffering from aridity or famine, the annual rainfall is high and the variability is low, the result naturally is prosperous agricultural conditions which in turn gives rise to a density of as high as 787 persons per square mile. In Ballia

In Bareilly and Cawnpore the variability is higher than the above districts and index of aridity is lower, the result naturally is that the density should be low. Bareilly in spite has not got such a low density as it should have. The factor which contributes towards a rise is the total amount of annual rainfall hence a density of 679 as against Cawnpore with similar other conditions but poorer rainfall which has only 512.

In the last two districts the variability is very high, index of aridity very low, annual rainfall is also low. The result is of course the poorest density as compared to other districts.

IRRIGATION IN RELATION TO RAINFALL
IN THE UNITED PROVINCE.

CHAPTER V.

Before discussing the various means of supplying irrigation, it is essential to understand thoroughly why it is necessary in a ~~tropical~~ country like India. Cultivation in the tropics can be, and in many cases is, effected by ~~retained~~ rainfall only, but usually some portion of the crop at any rate requires artificial watering, due either to ^{unsuitable} ~~improper~~ distribution of rainfall, as in Madras, or insufficiency of rainfall as in the Punjab and Sind. The average rainfall in Southern India varies from 40 inches to 60 inches which theoretically is quite sufficient for the successful growth of crops. However, artificial watering is always needed because the rains are badly distributed with reference to agricultural seasons and to the requirements of the crops. The ^{duration of} rainy season is short and it is not uncommon to have bursts of 8-12 inches in 24 hours. Even in the Himalayas or in the Montane region of this Province the crops grown on the terraces are often matured with artificial watering in spite of receiving from 50 to as much as 100 inches of rainfall. In the case of insufficient rainfall, crop production becomes a difficult problem. Such cases arise in Sind and parts of the Punjab where the rainfall of the year averages only from 10-12 inches and also in the ~~whole~~ basin of the Nile where rainfall over large tracts

is practically nothing at all. From the earliest stages of human civilization therefore man has devised many systems for carrying water to the land he cultivated. In tracts ^{of the plain} where rainfall ^{is} ~~was~~ inadequate irrigation ^{is} ~~was~~ usually effected by wells or by diverting the water of the streams. In ^{Deccan on the other hand} ~~other tracts~~ where the total rainfall ^{is} ~~was~~ ample but ^{is} ~~was~~ unsuitably distributed the storage of surplus water in tanks and reservoirs ^{came} ~~had~~ to be practised. ~~afterwards to be distributed on the fields during the dry season.~~

The rainfall in the Province decreases from east to west and from north to south and hence the south-western portion of the Province is the region with least rainfall. From a knowledge of climate we also know that this is the tract of greatest variability. The consequence is that this tract was the scene of disastrous famines prior to the introduction of modern elaborate schemes of irrigation.

Another important fact observed in connection with the Indian rainfall is that the tract receiving more than 70 inches of rainfall, e.g. Bengal and Assam, ^{usually} ~~never~~ requires ^{no} irrigation. If the rainfall is below 70 inches, then irrigation alone can secure the country against occasional losses of crops, though here also failure will never be evidenced at the same time over all the area.

From an economic point of view it can safely be said that millets and pulses derive little or no benefit from

BHOLA - POWER STATION.



irrigation except in an unusually dry year because the rainfall in the Kharif is sufficient to bring the above-mentioned crops to maturity without the aid of watering artificially. However, rice, and especially the transplanted variety which forms the main Kharif in the Submontane zone and in the eastern plains, will yield under irrigation an increased return of 20% in the former and 40% in the latter (1). Besides influencing the yield of rice, it is impossible to grow sugarcane without the aid of irrigation due to its high water content and hence high water requirement. The cotton yield is also influenced as we shall see in a later chapter. The early-sown irrigated cotton is greatly increasing in acreage in the canal colonies because of the high price it commands. Of the Rabi crops gram when sown alone does not require any irrigation. Wheat and barley give an increased yield of 50-100 per cent when irrigated. The opinion of the members of the irrigation commission regarding the protective value of irrigation can be appreciated from the following remarks:- (2)

"As to the protective value of irrigation it may safely be said that excepting the hill districts and a portion of

(1) Irrigation Commission Report, 1901 - 3.

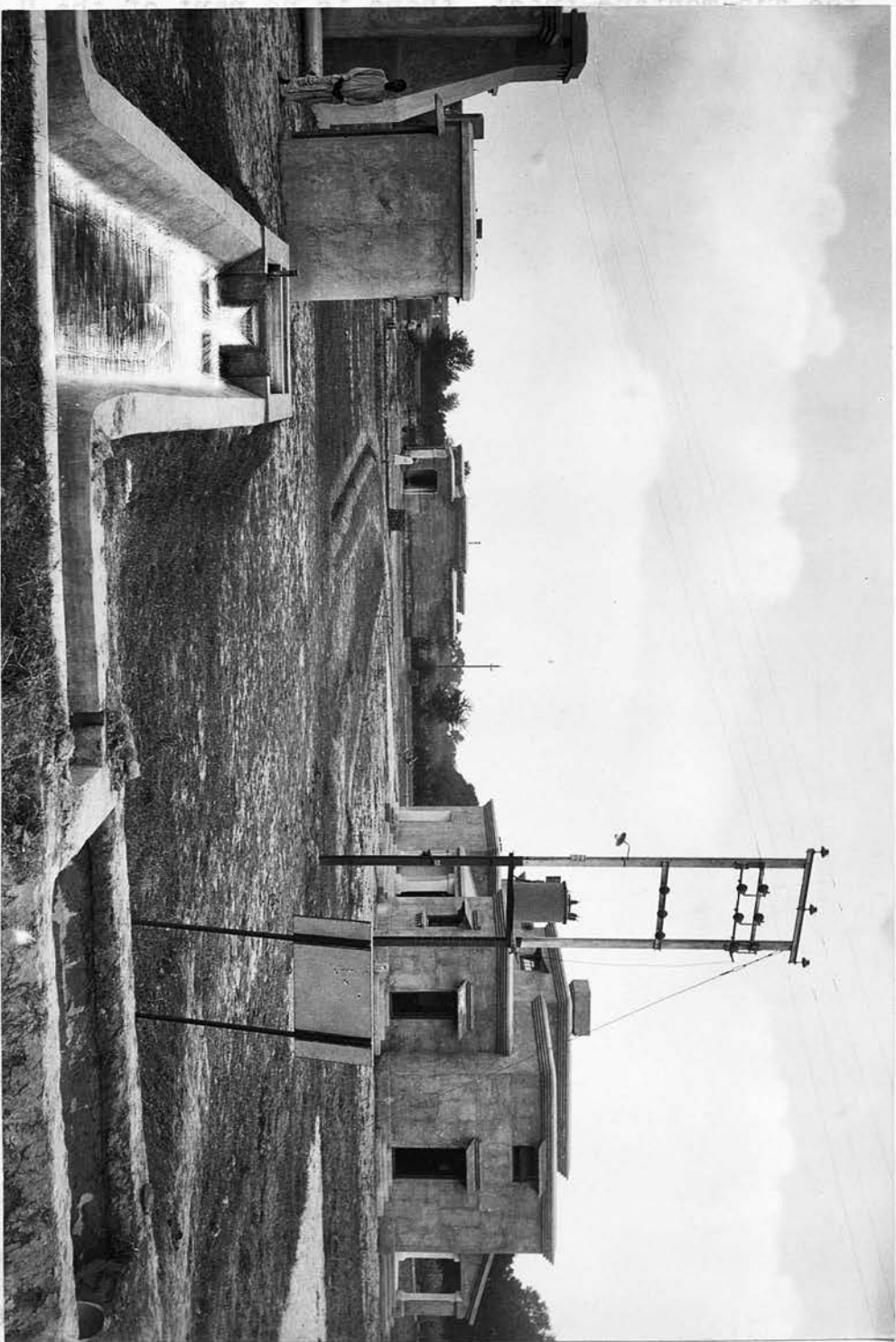
(2) Irrigation Commission Report, Op. Cit.

the sub-montane tract, there is no part of the U. P. which can be considered even fairly secure unless at least one-third of its cultivated area is protected by irrigation from a source which will not fail in a year of drought."

A careful examination of the statistics of rainfall, irrigation and cultivated area in the U. P. reveals on the one hand the striking dependence of agriculture on the rainfall and, on the other, the limits of irrigation. If the ponds and jhils have sufficient water due to good rains there is always less demand for sinking temporary wells. Well irrigation mainly depends upon the sub-soil water and the construction of masonry wells is out of the question in the Bundelkhand tract, south of the Jumna, due to very low water level. The precarious tracts of Agra, Muttra and Etawah districts make well-irrigation an expensive matter because of the low sub-soil water. A tube-well bored at Muttra had to go down 350 feet before an adequate supply of water was obtained. The area under well irrigation in the last named three districts is becoming smaller and smaller (1).

Over and above the sub-soil water there is the question of the nature of the water. Brackish water can do well for a ^rgrowing crop but is distinctly injurious to the germinating

(1) Season and Crop Reports of the U. P.



HYDROELECTRIC

SUB-STATION.

seeds, and may completely prevent germinating altogether.

On the whole it is found that the well-irrigation area is increasing showing thereby the dependence of agriculture not only on rainfall but also on irrigation. Canal irrigation does not usually increase in the same proportion as well irrigation ~~because~~ ^{because of the cost of installation of} probably ~~there is no scope for~~ canal schemes and the variable suitability of rivers for the purpose. ~~Improvement unless, of course, new schemes are developed to~~ ~~tackle the river water.~~

The only important and material increase in the canal area was effected in 1928 after the completion of the Sarda Canal scheme. The Province as a whole is indebted more to well irrigation than canal. At present/ ^{nearly} ~~over~~ half the total area irrigated is by wells. The plains are the tracts which easily lend themselves to their construction. Further, canal schemes are very expensive projects whereas the building of wells does not involve such heavy outlay.

There are only a few districts where canal irrigation supersedes that of wells and these are mainly in the west. Well irrigation is spread throughout the Province from east to west except in those areas where depth or the nature of sub-soil water does not make construction of wells and lifting of water an economic proposition. In the sub-montane ^{water} zone from Saharanpur to Gorakhpur the sub-soil/ is at a depth of 10-15 feet with the result that there is a preponderance of wells for irrigation purposes.

Rabi mainly depends on the winter rains, and when these

are deficient a resort to increased irrigation results. In 1924 - 25 the winter rains were deficient and the net irrigated area went up from 79.46 lakhs of acres in 1923 - 24 to 84.59 lakhs of acres or an increase of 6.5 per cent in the net irrigated area.

The canals are fed from the waters of the rivers rising in the Himalayas, the Ganges, the Jumna and the Sarada which are so harnessed that their total supply is used by the canals taken out from them. In the south the rivers rising in Central India irrigate an area of about 1.75 lakhs of acres "The perennial rivers have thus been, or will shortly be, put to their fullest use and any large extension in this direction cannot be looked for" (1).

It follows therefore that there is an increased dependence of agriculture, and therefore of continuous multiplication of population, not only on rivers, but also on the sub-soil water. If any additional area needs to be irrigated the only possible source is to tackle the remaining sub-soil water as the rivers have nearly all been tapped to their fullest extent. It brings/forward/therefore another important engineering problem which implies that there must be a steep gradient in the sub-soil water. However the tendency is for the level of the sub-soil water to be lower when compared with 2 or 3 decades back. The only possible solution

(1) Irrigation Commission Report, 1901 - 3.

for the preservation of the level of sub-soil water is that ~~the~~ rain water and canal water should not be allowed to run off into the rivers as is generally done at the present day, Moloney (1) suggests the following measures as possible remedies:-

(a) In the slack season of canals the surplus water should not be allowed to drain off and the tanks and jhils should be filled, when the pressure on the canals is not great. The irrigation water from such tanks and jhils should be charged at a nominal rate to encourage the village cultivators to fill in the tanks and jhils to be utilised in times of need.

(b) In the undulating country the practice of making embankments on the ravine lands should be encouraged.

(c) Proper attempts should be made regarding the downward movement of water to the sub-soil by excavation of swamps and construction of wells in the beds of tanks and streams, to make a direct communication between the surface water and the sand bed in the sub-soil. Draining down of the surface water into the sub-soil has all the advantages of surface drainage without its great drawbacks.

(d) Lastly all possible lands should be kept under the plough. This method is most successful though least

(1) Trend of Agricultural Development in U. P., Agricultural Journal of India, 1923, p. 23.

practised because of the immense cost.

The lining of water channels or reservoirs will go a great way in saving irrigation water. Great loss is caused by evaporation and percolation which can be reduced by lining the water channels with roof tiles (1)!

A considerable fall in the sub-soil water has rendered numerous masonry wells useless and the construction of new wells is beyond the purse of the average cultivator. Lifting of water from the wells is a very expensive matter, and so recently mechanical and electrical power pumping has been started/ ^{with Government assistance and loans.} ~~On/which~~ depends the future of agriculture in the Province.

A glance at the season and crop reports will show that the percentage of irrigated to total cropped land in the non-canal colonies has risen, indicating that probably the limit of well irrigation is near or has been reached in these districts where the technique of water lifting is bullock power or some other method.

Irrigation water can be made available by damming the river channels at the end of the rainy season. In dry seasons the streams are used for irrigation purposes if they contain water. Wells are and will remain the major source of irrigation as is evidenced from the above discussions. In general the tendency is for a rise in the number of masonry as well as non-masonry wells though in some parts a

(1) Radha Kamal Mukerji: Evidence taken in the U. P. for Royal Agricultural Commission.

shrinkage is visible, especially in the tracts south of the Jumna where the ground water supply is becoming more and more precarious and where canals of a protective nature are built to safeguard the needs of irrigation when tank irrigation fails.

Tanks and jhils are also the important sources of supply of irrigation water in the east of the Province, where the ^{are retained in view of the great population requiring this water} ~~pressure of population is most manifest~~ for its agriculture.

Distribution of population is correlated with food production areas or roughly the cultivated areas, hence the cultivated fields are encroaching upon those lands which are on the margin of cultivation, ~~and sometimes even those lands which have not yet been brought under cultivation~~. Such new lands when brought under cultivation require water for the growth of crops, with the result that a fall in the level of sub-soil water renders well-irrigation very precarious in that area.

The precarious state of the sub-soil water in Muttra and Agra districts before the introduction of canals might have been a source of danger to agricultural prosperity and those good lands which are under the plough to-day might have been useless waste had they not been served by the Mat branch canal. The introduction of canals has raised the ground water level and construction of wells has become possible. Great damage would have been caused if the ground water had been allowed to sink excessively (1).

(1) Molony: Note on the Level of Water in the Sub-soil of the Gangetic Alluvium.

Lane (1) in his settlement report of the Muttra district has described how the introduction of the new canal raised the water to its old level from 65 feet to 45 feet and averted a great agricultural calamity which a further fall would have caused.

The average area irrigated in this Province is about 10,000,000 acres out of which nearly half is from wells, about 3,000,000 from canals and the remaining 2,000,000 from other sources. The area irrigated depends largely on the incidence of long breaks in the monsoons which render irrigation very essential, especially in the case of rice, where a well distributed rainfall is very necessary. The Hathiwa (last showers of the monsoons) is very important to ensure a successful Rabi. In the absence of this irrigation again is very essential without which Rabi sowings are practically impossible. The low figures of the irrigated area in 1923-24, 1924 - 25 show that there was a well distributed rainfall and the exceptionally low figure in 1927 - 28 indicates that there was a good rainfall. The low figures for canal irrigation in 1933 - 34 indicate that there was a good rainfall in the canal districts in that year.

Canals Projects:-

The Eastern Jumna Canal was the first major irrigation

(1) Lane: Final Settlement Report of the Muttra District.

works in the Province, and is still one of the most important canals of the Province. The canal was taken off from the Jumna river at Faizabad and was completed in 1830 by the East India Company. It was actually first constructed during the rule of Shahjehan (1) and was finally remodelled and reconstructed by the East India Company.

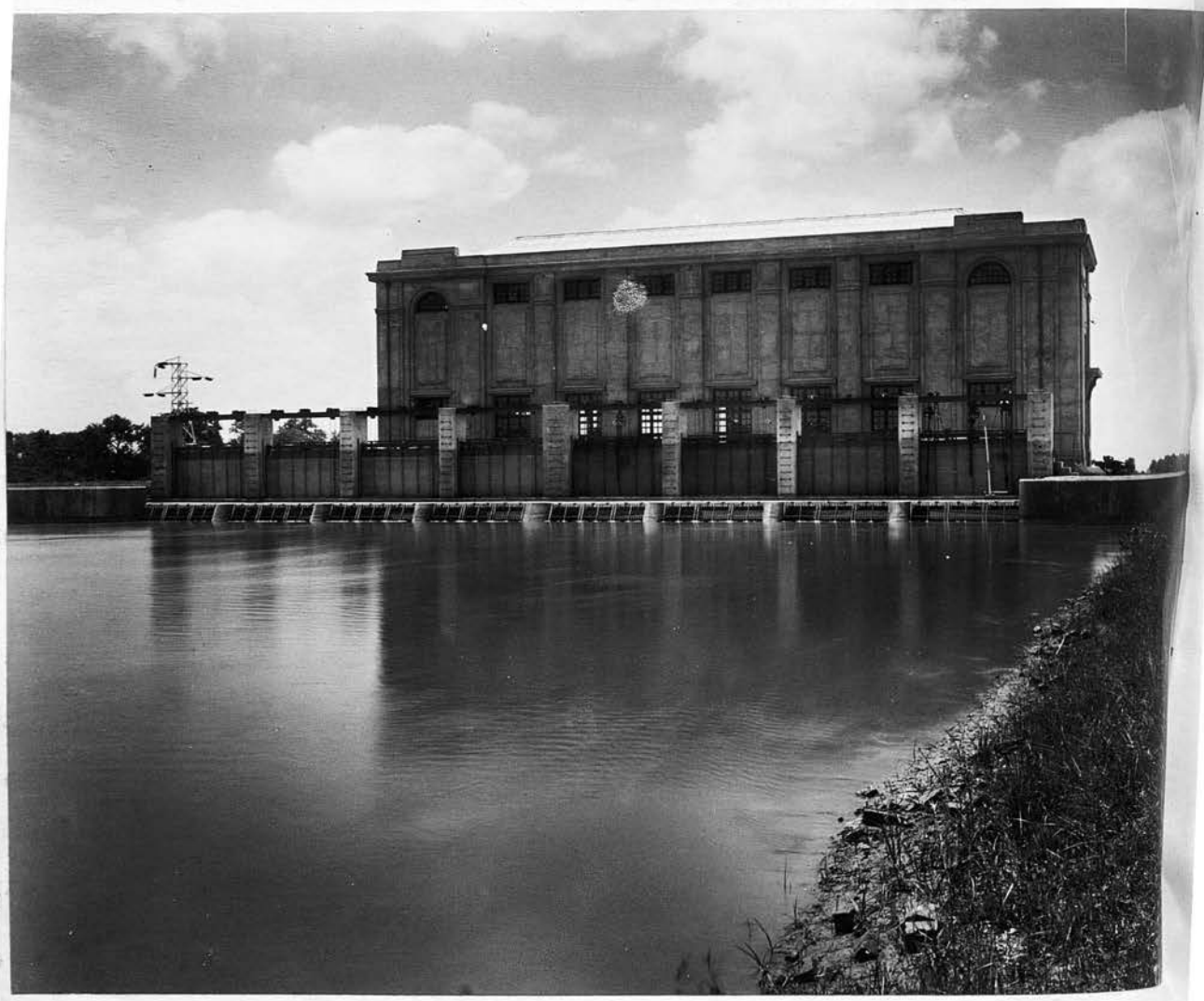
The Upper Ganges Canal was completed in 1854 and has its head-works at Hardwar. It irrigates over 1,000,000 acres (in 1934 - 35 it irrigated 1,179,071 acres) . It is also one of the most important canals of the Province. The name of Sir Proby Cautley, who prepared the scheme, will always be associated with this project. The canal has been brought to the Bangar (upland) of the Ganges - Jumaa doab and irrigates the whole of the upper and middle doab from the district of Saharanpur to Cawnpur. The main canal is 213 miles long, with branches and distirbutaries totalling 3,698 miles. Besides controlling and irrigating the fields, it serves the useful purpose of supplying water to Agra canal and the Lower Ganges canal on certain occasions.

The Agra canal was opened in 1874, and is taken off from the Jumna near Delhi. In 1934 - 35 it irrigated an area of 260,627 acres of land.

The Lower Ganges canal was completed in 1878, being

(1) R. B. Buckley: Irrigation Work of India, 1905, p. 13.

works in the Province, and is still one of the most important
canals of the Province. The canal was taken off from the
Jumna river at Rajpura and was completed in 1850 by the
East India Company. It was actually first constructed
during the rule of Shahjahan (I) and was finally remodelled



260,000 acres of land.

SALAWA POWER STATION.

The lower ranges canal was completed in 1878, being

primarily intended to supplement the supplies of the tail-end of the Upper Ganges canal. It is taken off at Narora (Bulandshahr district), the total length of the canal, including the branches and the distributaries, being 3,827 miles. In 1934 -35 it irrigated an area of 823,760 acres of land.

All the above four canals form the backbone of the existing canal system of the Province. They have the capacity of watering 3.25 million acres in the north-western part of the Province where the rainfall is variable and deficient and which is always badly in need of irrigation.

After the publication of the Famine Commission Report, protective canals began to be built. In 1885 the Betwa canal was opened in the district of Jhansi (Trans-Jumna). After 1880 attention was directed towards the Trans-Jumna rivers and the Ken and Dhasan rivers which were also tapped for purposes of irrigation. Reservoirs were constructed to hold the flood-waters. In 1906 the Ken canal was opened to supply the district of Banda, and in 1910 the Dhasan canal was completed to serve the district of Hamirpur. The above mentioned canals are only useful in the rainy season and are not directly remunerative but are insurance against famine and drought caused by long withdrawals or early cessation of monsoons. As a result 360,000 acres are being annually irrigated from these projects.

In 1918 the Ghagar canal was opened in Mirzapur district (Trans-Jumna east). Dhandraul Dam in the same district is, for purposes of irrigation, the largest reservoir in the Province.

In 1912 the Hathras branch of the Ganges canal was opened which has made secure quite an appreciable acreage of land in Hathras (Dt. Aligarh) and in Muttra district.

The Sarda canal is the largest productive work within this Province. It was completed in September 1928 and contains about 4,000 miles of main line and distributaries and about 1,700 miles of drainage channels. The headworks are situated at Banbassa on the border of Nepal, It is designed to irrigate the Sarda - Ganges doab. It irrigates Rohilkhand and the western part of Oudh.

The barrage at the headwork of the canal is the largest individual irrigation work in the Province. It consists of 34 sluice gates of 50 feet span each, giving a total breadth of waterway of 1,700 feet. It is the largest barrage of its kind in the Province with under-sluices right across the river. The canal is 350 feet wide in the upper reaches and is designed to carry 9,500 cusecs - the Ganges canal carries only 8,200 cusecs. After 4 miles the Jagbura river is passed by siphoning the whole canal discharge under the river through 28 reinforced concrete pipes, each $6\frac{1}{2}$ ft. in diameter. It is the largest work of its kind in existence

in the Province. The branch of the Sarda canal utilizing the supply from the Deoha river was opened for irrigation in 1925.

The Sarda system commands an area of about 6,000,000 acres of cultivable land and is designed to irrigate in the neighbourhood of 1,350,000 acres and it is believed to take about 10 years for the working of the calculated area.

Within the last decade a canal of 120 miles has been constructed in Bijnor and Moradabad districts, by damming the Ramganga river. A supply of 200 cusecs is pumped from the river to a height of 37 feet and the power required is taken from the Hydro-Electric Grid Scheme. The area commanded by this canal is anticipated to be about 100,000 acres and the area irrigated annually is expected to be 40,000 acres. ⁽¹⁾

Another supply of 100 cusecs has been obtained from the Kali nadi in Bulandshahr district. The power required is again taken from the Hydro-Electric Grid Scheme.

The canals, as is evident from the map, are mostly confined to the north-western part of the Province while the east remains without any canals since rainfall is sufficient to carry on cultivation. The truth is that, due to innumerable ravages of famine in the north-west of the Province, means had to be sought to stop the disasters caused by famines. The only possible solution was found in

(1) This canal could not be shown on the accompanying map of the canals as only the above information was received by the writer without any map.

the irrigation of cultivable land. Well-irrigation was already in progress but that could not cope with abnormal needs of irrigation and the only alternative was to dam the rivers and bring them to their fullest use for irrigation. ~~The north-western part of the Province, though having a smaller amount of rainfall, exhibits a higher standard of cultivation, due solely to canal irrigation.~~ With the opening of the Sarda canal the maximum area under irrigation has been reached. All possible rivers in the north-west of the Province have now been tackled and canals have been cut wherever the supply of water was most needed for raising good crops.

Advantages of Canal Irrigation:-

The canals have not only helped in raising the standard of agriculture but have materially increased well-irrigation by raising the water-level of the areas served by canals. They have materially increased the area of the cultivated lands by bringing under cultivation those lands that had hitherto remained uncultivated due to lack of water supply. They have helped greatly towards substituting better crops, e.g. millets could easily be replaced by cash crops like sugarcane or wheat. They have helped in increasing the value of the land as the productive capacity of the land has increased. The canals have given a greater security to the cultivators to fight famines and droughts with greater force

than before their introduction. They have also minimised ^{who} the dependence on rainfall and the cultivator/has a share in canal irrigation does not worry so much about late monsoons or their early cessation or the long breaks between the two falls. This mental happiness consequent on assured water-supply makes the cultivator bring about all possible improvements in the soil that lies within his means. It brings out the happiest results in the form of increased yields due to better manuring and better culture of the land.

An objection is often raised again canal irrigation. It is said that the canals have been built where already well irrigation was in progress. This may be true to a certain extent but the amount of confidence rendered to the cultivators by canal irrigation cannot be gauged by a casual observer. The amount of expense and labour involved in well irrigation is always tremendous and therefore reduces the margin of profit by increasing the cost of production. Canal irrigation has not only increased the margin of profit but has also helped in freeing labour for more useful purposes. The resulting economy of labour has helped to only produce an increase of population and increased cultivation. In other words, canal irrigation has not only fulfilled the needs of the individual cultivator but has also fulfilled the needs of the teeming millions as a whole. Besides, canal irrigation does not hamper well irrigation in any way

but rather helps it by raising the water level of the surrounding country. It will not be out of place to remind the reader of the effects of the Hathras branch canal in raising the water-level in the precarious tract of Muttra.

Injurious Effects of Canal Irrigation:-

One of the serious drawbacks which canal irrigation causes when the drainage of the land is not perfect is the formation of the alkaline deposits on the surrounding land. This is a serious handicap which is playing havoc especially in the districts of Aligarh, Muttra and Agra. The reason for the formation of the alkali lands is that the water level comes up in the canal area due to capillary action. Water with dissolved salts is brought up and is evaporated by the sun leaving a deposit of alkali salts. By continuous action like this the deposited alkaline salts become very hardened and remain little affected by the heavy monsoon precipitation. Apart therefore from bad drainage, the dissolved rain water has no chance of escape and is evaporated later on by the heat of the sun. As a result of this the salts do not diminish but rather accumulate. The only effect of monsoonal precipitation is that the low lying and ill drained soils get the maximum share of the alkaline deposits. These alkaline deposits are from cream to white in colour and are very hard, sufficiently hard indeed to allow motor cars and other vehicles to pass over without the

least jerk. To remedy these evils and to prevent further injurious affects it was found necessary to incur a considerable outlay on the relining of some of the older channels and on the construction of a comprehensive system of drainage channels. These measures have gone far to remedy, if not entirely to remove, the evils of which there were such serious complaints in ~~the~~ past years.

Malaria is another injurious consequence of high canalization and therefore bad drainage. Low-lying ditches never dry up because of the presence of water which acts as a harbouring place for mosquito breeding. Due care is now being taken to remedy this by the construction of new drainage channels and by draining the existing ditches, and it is gratifying to be able to record that the conditions in this Province are not so bad as in other provinces. Due attention has been paid to the problems of good draining in building the Sarda canal and advantage has also been taken in all cases of canal construction of the natural drainage of the Province.

Remedy of the Injurious Effects of Canal Irrigation as Suggested by Radha Kamal Mukerji (1):-

1. "Though the canal system is extensive, there are few districts where canal exceeds well irrigation. Moreover, the canal seldom enables a full Rabi area to be sown in years of drought when the additional water required has

(1) Radha Kamal Mukerji: Evidence taken in the U. P. - Royal Agricultural Commission.

to come mainly from the wells. Thus there is a considerable scope for assisting the construction of additional masonry and temporary wells.

2. Various canal tracts suffer from defective drainage and over-saturation. In some areas (adjoining the main branches) agricultural depression follows the spread of Reh^(alkali) while in others a rise in the water level occasions the falling in of non-masonry wells. Improvement of channels of the minor streams and the opening out of arterial lines has to be undertaken on a systematic scale and is expected to result in mitigating the danger to agriculture from water logging and salt encrustation.

3. Over-irrigation results in loss of water and poor cultivation. Sometimes it adds to the useless alkali lands requiring an expensive drainage system for its reclamation. Water requirements of crops should be studied and possibilities of water saving by a combination of fodder production and improved methods of agriculture should be explored on irrigated regions. The Japanese system of providing canals for the proportional distribution of water and the construction of discharge canals may be adopted.

4. Rainfall being the limiting factor in agriculture afforestation and suitable crop production in sandy tracts will prevent further arid conditions. The introduction of defensive vegetation against sand will contribute to reclama-

tion of new lands or to the increased fertility of the old. ^{Sand, from the} ~~the~~ districts ^{of} ~~the~~ south-west sandy plains ~~are~~ ^{is} extending towards the north-west due to deforestation and westerly winds. Nothing but a chain of forest reserves can hinder further expansion. Deforestation has destroyed the equilibrium of climate and the hydro-graphical condition of the tract resulting in agricultural danger for the future".

5. So far there is no arrangement for the supply of water to the cultivator by measurement, the result is that invariably extra water is put on the fields. This is not only a loss of water but deteriorates the crop as well as the soil. It is therefore suggested that some means should be devised whereby the required amount of water can be supplied to the cultivator. It ^{was} ~~has been~~ estimated that about 50 per cent of the water ^{was} ~~is~~ ⁵ wasted by the farmers" (1).

One of the greatest indirect advantages derived from the canals is the development of hydro-electric power which the falls provide within the course of the canals. These falls also provide motive power for mills. The canals afford grazing areas on either side of their banks. In Bundelkhand the canals help in filling the tanks which at a future date are going to be used for purposes of irrigation.

The most important and the most ancient source of

(1) See W. Crooke: The North-west Provinces of India, p. 150.

irrigation is the well. South of the Jumna the rocky nature of the ground results in water issuing from fissures but in the Gangetic Plain the sub-soil contains an almost inexhaustible supply of water and it is easy to excavate the alluvium. This is the general source of irrigation throughout the Province though the depth of the water-level varies from 10 to 100 feet.

The masonry wells are mainly concentrated in the eastern districts. In the north-western part of the Province and, with the completion of the Sarda canal, in the whole of the western tract there is ample canal irrigation whereas in the east which has few canals, the wells are the most important source of irrigation. The Doab lands in the north-west which are far removed from the line of canals are studded with non-masonry wells as a continuous and heavy supply of water is not usually required. Also, it is cheaper to ^{sink} ~~excavate~~ a non-masonry well, being within the means of even a single cultivator; hence the concentration of such wells. Where a heavy supply is needed, tube wells have been brought into operation. The cheap hydro-electric power is also available in this tract and hence the concentration of tube wells in this area.

The impetus given to tube well boring in this region is based on two facts (a) cheap energy available for working the tube wells and (b) assured supply of sub-soil water. All

rivers do not lend themselves for canalization and those that are favourable have already been tapped. For further advancement we have therefore to look to the sub-soil water supply. About one-third of the total rainfall reaches the sub-soil (1). Theoretically therefore the sub-soil water is replenished each year by about 12 inches. Since the limit in canal irrigation has almost been reached, tube wells to tackle the sub-soil supply of water have become an absolute necessity.

Before proceeding further, there is one other point of importance to be discussed. Meerut, Muzaffarnagar and a part of Bulandshahr districts have under their control a very good supply of sub-soil water and if this water could be used to the fullest extent an appreciable amount of canal water could be freed which could be utilized for the dry and precarious districts of Muttra and Agra. Furthermore the salvation of the multitude, in the absence of coal, iron and other similar raw materials, depends on agriculture and its associated industries, and therefore the problem of systematic irrigation in the region of uncertain rainfall is of prime importance. The development of a hydro-electric scheme in the Province, it is hoped, will go a long way towards the prosperity of the Province and its people.

(1) E. A. Moloney: Note on the Level of Water in the sub-soil of the Gangetic Plain - Bulletin XXXIII: Dept. of Land Records and Agriculture U. P. 1915.

Sugarcane is being transported on a 2' gage - over the KALI NADI.



Forty-five sub-stations have been built for 75 state tube wells in Moradabad, Bijnor, Meerut and Bulandshahr districts and power is also available for private consumers. 2,200 H.P. is also supplied to the 4 pumping stations of the irrigation department, thus enabling 400 cusecs to be pumped from the Kalinadi, Ramganga and Gangan rivers for irrigation in the various canal systems extending into the hitherto arid areas. This scheme provides for 1,500 tube wells with their distributaries, channels and subsidiary works. It ensures protection for 1,500,000 acres of dry areas in the 7 districts of Moradabad, Bijnor, Saharanpur, Meerut, Muzaffarnagar, Bulandshahr and Aligarh. These tracts have so far remained without canal irrigation as a result of water shortage in the 3 canal systems of the Ganges, Jumna and Ramganga. These facilities which are provided to the private consumers will, it is hoped, greatly improve the irrigation leading to the improvement of crops and also release, for better cultivation of the soil, the labour that has so far been employed on the wells. The increase in the irrigated area of the non-canal tracts of the above 7 districts will testify to the utility of power pumping especially in Moradabad, Bijnor, and Meerut districts. The cost of lifting the sub-soil water is much cheaper than either by bullock power or manual labour. "The cost of tube-well irrigation was one-third of the cost of raising water by

strata which is one of the essentials for successful tube-well boring. The sites selected for these tube-wells were those that had^{an} assured future for higher standard of agriculture but the potentialities could not be fully demonstrated due to lack of water supply. The size of each tube-well had been standardized at $1\frac{1}{2}$ cusecs and each tube-well could command an area of 1 square mile. In 1935-36, 118,730 acres were irrigated by state^{tube}/wells. The number to date constructed is 814 and by the end of 1937, when the present scheme will be completed, 1,500 tube-wells will be in operation.

Operating expenses are higher in the case of tube-wells than canals but they possess their own advantages. A tube-well boring can be made wherever needed and only where needed. In tracts of intensive cultivation many tube-wells can be centred round that area, while in tracts of extensive farming one tube-well may be sufficient to control a large area (1).

When completed, these 1,500 tube-wells will protect 2,900 square miles and will irrigate 482,460 acres of Rabi, 182,750 acres of sugarcane and 87,720 acres of other Kharif, making a total of about three quarters of a million acres.

(1) The Ganges Valley State Tube-well Scheme - Sir William Stampe, 1936, p. 5.

'charsa' and two-thirds of that by hand" (1).

It is often said that the cultivator has not to pay anything extra for the upkeep of bullocks as he has to feed them in any case. This statement is quite true but one should not forget that the bullocks could be put to better economic use, such as, ploughing extra land or harrowing the fields or carting the produce to the market as is customary in the canal tracts. It is evident therefore that a supply of power to the tube wells will enhance irrigation possibilities leading to a better standard of agriculture and higher yield.

The Hydro-electric Grid Scheme was started in 1929 over the western districts and by 1931 various privately-owned tube-wells were installed. From 1931 to 1934 Rs/470,000 were spent on 95 experimental tube-wells. A committee of experts decided that the results of the experimental tube-wells were very favourable and individual tube-wells could very profitably assist in furthering irrigation.

Ganges Valley Tube-Wells:-

As a result of the report of the Ganges Valley Tube-well scheme the government undertook the scheme very seriously. The western districts were particularly fortunate in having heavy layers of coarse water bearing sand in their

(1) Minutes of the Tube Well Conference, July 1934, Irrigation Department of U. P. p. 11.

By the end of 1937, on completion of the Ganges Canal grid, it will have developed 27,900 K.W. For areas that do not have an assured sub-soil water supply or where tube-wells are not a success, water pumping from the rivers has been taken recourse to, which will release water for irrigation to the districts that lie outside the grid area. One tube well can command (a) 330 acres of Rabi or (b) 151 acres of sugarcane or (c) 60 acres of Kharif and 125 acres of sugarcane.

From a study of the conditions discussed above, it is clear that the western part of the Province is being richly served by the tube-well schemes in spite of high canal irrigation in that tract, whereas the eastern districts are getting no share of canal or tube well irrigation. It is often said that the cultivators of the eastern districts have not learnt the art of irrigation so well as their fellows of the western districts but with the progress of irrigation projects in the east they will soon learn it and their present lack of knowledge of the art of irrigation will not be a serious handicap for them. The chief reason for the heavy concentration of canals and tube-wells in the western districts is that there the necessity for irrigation was and still is more pressing due to a lower and more precarious rainfall than in the east.

An electrification scheme using the falls on the Sarda

canal for gridding the eastern districts has been examined. Trial tube-wells have been sunk but the strata has definitely been found to be unfavourable. A scheme is being put under operation for pumping water out of the Gogra at Raunahi near Fyzabad, for irrigating a portion of the Gogra-Gumti, doab. This provides for a power station of 1,250 K.W. and a pumping station to raise 160 cusecs from the river into 113 miles of main canal and distributaries.

Other schemes under consideration are:-

1. For pumping 140 cusecs from the Jumna at Bhikau near Allahabad.
2. For pumping 220 cusecs from the Ganges at Manikpur north of Allahabad and
3. For pumping 560 cusecs from the Ganges at Adampur, about 50 miles east of Cawnpore.

The Effect of Progress of Irrigation on the Pressure of Population.

It is but natural to expect that the percentage of ~~cultivated~~ area irrigated from different sources is higher in those districts which have relatively simpler irrigation due to high water level and hence preponderance of jhils and marshes. Difficulties in well construction and also in the lifting of well water and the limitations of canal cultivation manifest themselves in the districts having a deficient and variable rainfall as will be evident from the following

table:-

1930 - 31 to 1934 - 35.

Dists. arranged accord- ing to density	Density per sq. mile, in 1931	Density per sq. mile, in 1921	Normal R.fall	% of irriga- ted to total cropped area	% of area cropped more than once to total cul- tivated area	% of irrigated area cropped more than once to total area cropped more than once.
Benares	930	898	39.99	37.6	28.4	1.7
Lucknow	814	749	36.00	31.6	22.2	12.0
Jaunpur	797	745	40.62	57.2	26.3	3.0
Gorakhpur	787	721	48.15	37.4	31.4	0.7
Ballia	742	679	41.45	35.2	27.1	2.4
Basti	737	687	47.67	44.5	35.5	0.3
Azamgarh	710	690	40.40	56.5	25.9	2.5
Meerut	699	652	28.10	48.6	27.9	28.2
Bareilly	679	642	44.48	16.4	21.2	2.0
Ghazipur	634	597	39.55	31.3	20.3	2.0
Aligarh	602	545	25.09	48.7	21.9	36.2
Bulandshahr	595	560	26.00	46.4	29.5	36.7
Agra	567	500	25.09	26.8	12.2	15.0
Moradabad	561	524	38.39	8.0	11.3	2.8
Muzaffar- nagar	541	480	29.69	47.0	23.3	21.7
Cawnpure	512	485	31.99	32.2	14.9	24.2
Etah	501	483	27.63	43.6	18.4	36.3
Saharanpur	489	440	36.98	22.6	27.7	5.5
Muttra	461	427	23.63	37.0	13.1	30.9
Mainpuri	448	446	29.73	50.3	18.9	33.7

The above table affords a very interesting insight into agricultural productivity and development in relation to normal rainfall and the facilities of irrigation. It also gives an idea of the relation of double cropping to these factors.

Of all the districts indicated in the table Benares and Lucknow seem to be most populated in this Province. The pressure of population here is not mainly agricultural in

nature, because although these districts embrace the least area within them, their towns have large populations. The natural result is therefore greater density. Then come Jaunpur, Gorakhpur, Basti, Ballia and Azamgarh which also show considerable density of population. This is plainly correlated with higher normal rainfall and higher percentage of irrigated and double cropped areas. The seasonal rainfall varies very little throughout the above tract. There is some rain, in the first four months, and May invariably gets rain. The Hathiwa rains in this locality give a greater assurance for Rabi. In the west Meerut takes the lead in the density of population, Muzaffarnagar, Bulandshahr, Aligarh, Saharanpur, Bareilly, Mainpuri and Etah are the districts which are fairly well protected by the canals. The rise in density in these districts is very considerable and gives a clue to the fact that the density is governed not only by abundant normal rainfall but also by the security and protection given by the canals, or some other easy means of irrigation, ~~even the Hydro-Electricity Scheme and the construction of permanent tube wells as in the tract especially at Moradabad, Bijnor and Meerut.~~ There also appears some relation between the double cropped area and the density of population, Such correspondence between high density and increase of cultivated area and double cropping is not suprising. Parts of the Province support

nearly twice as many persons per sq. mile as in agricultural Europe. The many-sided agricultural activity around big towns such as Benares and Lucknow will naturally support a very high density due to the intensification of agricultural activity. The above-mentioned agricultural towns have a density ~~population~~ which is probably one of the highest in the agricultural world. The table also bears out the fact that in places where rainfall is defective, intensive irrigation has not been able to take the place of natural rainfall if we judge by percentage of multiple-cropped area. The high percentage of irrigated land to total cultivated area in Muttra and Mainpuri could have but little effect on multiple cropping and density. The same is true of highly canalized districts, e.g. Aligarh and Cawnpore because a limit of canal irrigation has probably been reached as the engineers have already tackled all possible sources of river water; so also the limit of well irrigation has been reached in the tract south of the Jumna due to high cost of construction of the wells as well as the greater depth of sub-soil water.

The higher density at Bareilly can be explained as due to the Rohilkhand canals and high rainfall. The greater density at Moradabad can similarly be explained as due to accessibility to the subsoil water and sufficient rainfall.

A more detailed survey of the correlation between water supply and density will reveal two factors coming into

play (a) In districts where normal rainfall falls below 32 inches irrigation becomes the main limiting factor to density of population. (b) In districts where irrigation falls below 25% of the total cropped land it ceases to be the determining factor of agricultural productivity and rural density.

Districts with more than ^{40%}~~100%~~ of irrigation but less than 32 inches of rainfall. Density.

Meerut	699
Aligarh	602
Bulandshahr	595
Muzafarnagar	541
Etah	501
Mainpuri	448

Districts with less than 25% of irrigation but more than ~~40~~ inches of rainfall. Density.

Bijnor	466
Bahraich	431
Kheri	318

Districts with over 25% of irrigation and over 32 inches of rainfall. Density.

Benares	930
Jaunpur	797
Gorakhpur	787
Ballia	742
Basti	737
Azamgarh	710

The preceding table affords a clear justification of the theory already advanced. Irrigation below 40 per cent fails to have any appreciable effect on the density unless the rainfall exceeds 32 inches. Over 40 per cent of irrigation mitigates the effect of deficiency of rainfall. Aligarh, Bulandshahr and Mainpuri with 50 per cent of the total irrigated land supports a relatively low density as their average rainfall falls below 32 inches. On the other hand ^{BIJNOR} ~~Bijnor~~ and Bahraich have a good rainfall of over 43 inches but support a very low density of population due to lower percentage of irrigation. Districts like Ballia, Azamgarh and Jaunpur, having a lower rainfall than the last mentioned districts but with more irrigation, represent a state of superior farming and higher standard of agricultural prosperity.

In spite of very great progress in the development of irrigation works in this Province, the variability of the monsoon causes a general reduction in the area under Kharif crop. The greatest danger exists in the eastern sub-montane tract of Basti and Gorakhpur where private owners have gone so far as to construct their own canals for irrigation. In spite of this the shrinkage in the Kharif area seems to be great in the whole Province due to uncertain rainfall. Late rice of better quality can only be sown with the aid of irrigation and an uncertain rainfall will not only reduce

the Kharif area but will effect the Rabi as there will not be enough time left for Rabi preparations. As a rule the early broadcast variety of rice predominates in the east, while only Basti and Gorakhpur produce a finer quality of rice due to the enterpr^eise of the local land-holders in the form of construction of private canals.

Eastern districts north of the Gogra are protected by very high rainfall. These districts may be compared to the canal districts of Saharanpur, Muzaffarnagar, Meerut and Bulandshahr which have multiplied enormously during the last 3 decades.

The percentage of the irrigated area to the total cropped land is greater in the non-canal tract of the east than the canal tract of the west. It is also significant to note that greater facilities exist in the non-canal area due to high water level and because of greater protection by rainfall. However, the entire area of the non-canal district is given over to rice cultivation which causes a serious anxiety to the cultivating classes. Failure of rice will eventually lead also to the failure of Rabi as has already been discussed. The districts of Jaunpur, Azamgarh, Gorakhpur, Basti and Benares show a much larger irrigated area than the canal districts. The area is specially suited to the sinking of permanent as well as temporary wells. The greater agricultural prosperity of

the Kharif area but will effect the Rabi as there will not be enough time left for Rabi preparations. As a rule the early broadcast variety of rice predominates in the east, while only Basti and Gorakhpur produce a finer quality of rice due to the enterprise of the local land-holders in the form of construction of private canals.

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the non-canal districts over the canal area can be seen from the following table:-

Non-Canal Dists.	% of double cropped to net cultivated land.	Normal rain-fall.	% of increase of density of population from 1881 - 1931.
Benares	28.4	39.99	8.1
Jaunpur	26.3	40.62	2.2
Gorakhpur	31.4	48.15	37.2
Basti	35.5	46.67	27.4
<u>Canal Districts</u>			
Meerut	27.9	28.09	23.3
Muzaffarnagar	23.3	29.67	18.2
Bulandshahr	29.5	26.00	23.0
Aligarh	21.9	25.09	14.7
Etah	18.4	27.66	13.8
Mainpuri	18.9	29.76	6.4

The non-canal districts mentioned above in the table show a higher percentage of net cultivated as well as double cultivated area to the total cropped land, though it is true that the former districts have a greater certainty of rainfall as compared to the western districts. However to the natural advantage of the rainfall has been added the continuous human effort towards the development of irrigation schemes providing facilities for irrigation. On the whole therefore one expects relatively greater agricultural progress and increase of population in the former districts than in the latter.

GENERAL AGRICULTURAL PRACTICES.CHAPTER VI.

Agriculture is and will always remain the main industry of the Province as about three-quarters of the population is directly or indirectly dependent on it. In the absence of raw materials like coal and iron, agriculture is the only salvation of the population, although hydro-electric may replace coal to a certain extent as in Nepal.

Out of the total area of 68,000,000 acres of the Province, about 35,000,000 acres are cultivated by roughly the same number of persons so that an acre per head is the average cultivated area. The size of the holding in the western part of the Province is larger than in the eastern being $6\frac{1}{2}$ acres in the former and 3 to 4 acres in the latter (1). The above holdings are not compact and are scattered (2) throughout the village to the great disadvantage of the farmer. The holdings are usually small and scattered though big compact holdings do exist. The Taluqdars of Oudh have large holdings but they are in all cases rented to the smaller cultivators who have fair security due to the

(1) See Agricultural Holdings in the U. P. - H.R.C. Hailey, A.J.I. Vol. XIV, pt. 4, 1919, pp. 526 - 535.

(2) See The Realignment of Agricultural Holdings - B.C. Burt, A.J.I. Special Indian Science Congress Number 1916, pp. 33 - 39. Also The Consolidation of Agricultural Holdings in the U. P. - H.S. Jevons, A.J.I. Vol. XIII, pt. 2, 1918, pp. 212 - 230. Also The Consolidation of the Scattered Holdings, A. & G.L.C. Howard, A.J.I. Vol. VI, 1913, pp. 111 - 117.

Oudh Tenancy Act. The obvious deterioration in the size of and consolidation of holdings is caused by the present Law of Inheritance. Competition for land further favours fragmentation. Extremely small holdings are not only characteristic of India, they are common in Europe and elsewhere. An extensive system of cultivation is practiced in the U.P. (1) due to less resources and greater dependence on rainfall whereas in Europe ~~it is~~ intensive and specialized cropping is the general rule.

The agricultural year is divided into Kharif (autumn or rainy season) and Rabi (spring or winter). The former starts with the first shower of rain sometimes in the latter part of June or beginning of July or even ⁱⁿ the middle of May for the irrigated districts, and the latter commences in October when the rains are over.

Roughly our agricultural activities start with the monsoons. A couple of weeks before this, the farmers busy themselves in manuring their fields, making embankments etc. With the advent of rains ploughing of the parched fields begins and soon after this the Kharif is sown. Due to the warm moist conditions prevailing at that time of the year an extremely rapid growth of the crop is effected and in a few weeks time the countryside is full of green vegetation. While the Kharif is growing, the fallow lands meant for Rabi are given the rainy season cultivation.

(1) See Fragmentation of Holdings as it Affects the Introduction of Agricultural Improvements - B.C.Burt, A.J.I. Vol. XIV, pt. 4, 1919, pp. 536 - 540.

The Indian monsoon has produced two important results. "In the first place the heavy falls of rain, which often occur, lead to constant erosion and to the loss of the moist fertile portion of the soil. In the second place the duration of the monsoon is so short that only rapidly-maturing varieties of low potential yield can be cultivated. The annual loss of soil which takes place in India by erosion is immense and is an important factor in reducing the harvest" (1). The main factor causing the loss of soil is that much of the rain is received in heavy sudden falls which are not properly distributed so that a large portion of this is allowed to run off, carrying with it a portion of soil fertility leaving the soil poorer in quality which in turn effects the crop. Sometimes the drainage from the higher lands causes a water-logging in the lower land before it reaches a drainage line or a river. In other cases the surplus reaches the river so rapidly that it cuts unnumberable gullies and ravines and washes away the soil without ever managing to soak into the sub-soil. The result is that the sub-soil is not replenished with the supply of water which is so much needed for the successful cultivation of crops in this Province. Besides, as indicated on the 1/M Land Use Map, large areas have been converted into useless ravines

(1) Indian Agriculture - A. & G.L.C.Howard, 1927, p. 13.

especially on the left bank of the Jumna. It is hoped however that the afforestation carried out by the Forest Department will prove successful, but the areas devastated so far are too large to be rapidly reclaimed in this way. All these adverse factors - soil erosion, water-logging, shortage of sub-soil water and formation of ravines - occur because there is no adequate control of rainfall after it reaches the ground. With a well-distributed and light rainfall all the above factors are minimised and the fields produce bumper crops even when the average rainfall is below the normal.

With the cessation of the monsoons in October, the skies become clear, the temperature begins to fall, and the Kharif becomes ready for harvesting. The Kharif harvest continues till November and in the case of cotton may continue as late as January. In irrigated tracts where two crops are harvested in a year the Rabi sowings are done immediately after Kharif harvest, but in non-irrigated tracts where the moisture is not sufficient to ensure a successful Rabi, the fields are left fallow and as a rule Kharif in the first year and Rabi in the second is grown. The growth of the Rabi crops is not so rapid as that of the Kharif. Temperature rises in March and Rabi is ready for harvesting from the middle of March to early April.

With normal and well-distributed rains the farmer has

every reason to believe that he is going to harvest a rich crop though he can never be certain since anything unusual may upset the equilibrium with unfavourable consequences. Frosts by night in January or February and hail by day in March or April may destroy the crop partially or completely. Wet weather in February or March favours the growth of fungus in the crop. Strong westerly winds in March shrivel the crop and reduce the yield.

Heavy rain/ⁱⁿthe beginning followed by an interval of fine weather is ideal for field work. Copious rains in July and August and light showers in September and one or two heavy falls in the end of September or beginning of October mean a well-distributed rainfall. Any wide deviations from the above may mean disaster to the farmer. If for example rain sets in late, it means poor Kharif yield. Long gaps between two falls and strong sunshine necessitates the use of artificial irrigation. At times early cessation of rains is the greatest misfortune for the Rabi sowings. Heavy continuous rains in October may cause water-logging and loss of nitrogen from the manures already applied. Unusually heavy rains in July and August may even cause water-logging of the roots of the standing Kharif crop (1).

The plain of the Province receives on an average about

(1) Drainage and Soil Aeration - A.E. Parr, A.J.I. Vol.VII, pt. 4, 1912, pp. 371 - 372.

36 inches of rainfall per year which is sufficient for raising ~~the~~ Kharif crops. Rabi and sugarcane invariably need irrigation to bring them to maturity and even Kharif sometimes requires irrigation, when there are long gaps between falls. With a normal monsoon and proper tillage it is not impossible to grow Rabi crops without irrigation. Wheat has successfully been grown with only one irrigation. 10,000,000 acres or about one-third of the total land under crop is irrigated. The irrigation schemes have greatly added to the agricultural prosperity of the Province. Highly canalized districts which were once the scene of disastrous famines and scarcities are today smiling with green fields and have taught the world a lesson in irrigation by exhibiting a high standard of agriculture. Some districts have as high as 80% of crops under irrigation.

Scrutiny of the Season and Crop Reports reveals that there is a tendency for the acreage of Rabi crops to rise with a normal and well-distributed rainfall and to fall with uncertain rainfall. The Kharif is only effected when there is either early cessation or long withdrawals, and it remains unaffected in the case of belated monsoons. Furthermore a normal rainfall tends to leave the field ready in good time for the Rabi preparations. Early cessation or withdrawals extending over two or three weeks with much sunshine dry up the fields quickly and necessitate artificial

irrigation. At that time of the year this is a very serious proposition as all the labour and the motive power is utilized in rainy weather cultivation of the fallowlands and in conserving the soil moisture, whereas belated monsoons do not affect the Kharif crops, because they do not damage these but simply delay the sowing and consequently the harvesting. The result is to leave no margin for the already short sowing season for Rabi/^{crops.} Hence we may say without much fear of criticism that a successful season of the monsoon is the limiting factor for the acreage under Rabi crop, or in other words for general agriculture because the important cash crops are usually the Rabi crops. Summing up it can be said that successful monsoon is the key-note to the prosperity of the cultivators.

Nitrogen as a Limiting Factor:-

The alluvial soils of India are well above the average fertility. The truth of the above statement can be measured from the heavy cropping to which the Indian fields are subjected and to the small quantity of manure that is supplied to the soil annually. The only defect of the Indian soils is that they are deficient in nitrogen because the organic matter is so poorly applied. Given a sufficient supply of nitrogen the soils can compete with any type of soils as far as fertility is concerned. The only organic matter applied to the soils is in the form of farm-

yard manure. The pernicious practice of burning cowdung (1) in place of fuel has time and again been shown to deteriorate and lower the standard of fertility of the soils of India. This injudicious practice must be uprooted either by educating the masses against the evil effects, or through legislation. The cultivators should be provided with fuel for their needs. All villages of the Province have some sort of reserve fuel, either the Dhak (*Bhutea frondosa*) or Babul (*Acacia Arabica*) 'jungles' which can be placed at the disposal of the cultivators. Increase of this resource will partially settle the problem of burning the soil fertility in the shape of farmyard manure. Again the ashes from all hearths should be applied to the fields which though not very adequate manures will help to tone up the soils a little. The utility of green manuring has been much emphasized by the different Agricultural Commissions and the Department of Agriculture and it is pleasant to be able to record that the cultivators are taking to this seriously. The writer in his own farm was able to get only about 10 maunds of wheat from an acre plot until it was green-manured with sun-hemp when the yield was increased to about 14 maunds. It is only fair to admit that the increase may not have been due to green-manuring alone as the preceeding monsoons of the

(1) Cattle Manure - D. Clouston, A.J.I. Vol. II, pt. 3, 1907, pp. 261 - 269.

year under enquiry were fairly well distributed and the increased yield certainly had something to do with the rainfall. But the writer considers an increase of 40% could not be due only to well-spread monsoons and that green-manuring had certainly some effect on it too. Many government farms also have been able to record an increased yield due to green-manuring. It is not very convenient to practice green-manuring where intensive cultivation is in vogue but in farms under extensive cultivation it can safely be used. Farms with specialized and intensive cropping need to utilize the soil to the fullest, continuous raising of crops with aid of manure is the chief feature of such farms. Cultivators of such lands therefore are not in a position to wait for two months to grow the green-manurial crop plus a further six weeks to two months during which it is ploughed down and remains within the soil until the nitrogen is made available to the soil. In other words, the field has to be left without any crop for four months which means a positive loss to the cultivator. Continuous farming is only possible round about big towns where plenty of manure in the form of night soil and sewage is available. It will not be out of place to remind^{the} readers of the importance of 'town circles' regarding the intensity of farming in the soil maps of the few districts prepared by the writer on the basis of Settlement Reports. The fields situated

far away from the towns can profitably take up green-manuring where one crop in a year is expected.

Some intensive cultivators use oilcake which is manufactured as a by-product after the extraction of oil. The cakes form very good cattle food and also are excellent manures. It is only the question of relative importance which should determine the use of oil cake; where the cattle need it more it should be utilized as a cattle food, elsewhere it can with profit be applied to the fields. It is undoubtedly a very good substitute for farmyard manure and in fields that are deficient in nitrogen, oil cakes are very useful as their nitrogen percentage is higher than that of farmyard manure.

The modern development of compost has proved its high qualities as a nitrogenous manure. Usually the dry matter is mixed with green weeds and leaves of trees during the rainy season and the heap is turned twice or thrice before it is converted into a natural manure (1). The whole process does not take more than six weeks. This is a very easy means of getting a natural manure at the cheapest cost as it does not involve either a laborious process or high expense. This manure can very well serve the needs of Rabi and it will really be a healthy sign to see all agriculturists have a compost pit where they can store the compost for

(1) Farmyard Manures - Its Making and Use - E.J.Russell, A.J.I. Vol. XV, pt. 6, 1920, pp. 667 - 672.

future use.

Artificial manures, such as sulphate of ammonia received from the coal fields, are not used in India, but are mostly exported to Java and the Straits Settlements. Similarly, crude saltpetre, though produced in India, is not used to any great extent/^{and} even bones are usually exported.

The importance of pulses or leguminous crops in enriching the nitrogen content of the soil has been so fully studied by students of agriculture that it is not proposed to devote much attention to it here. Suffice it to say that the legumes form an important basis for rotation in Indian agriculture and every cultivator rotates them with a cereal. This subject was also fully reported on at the meeting of the Indian Science Congress at Lucknow in 1923.

Other soil organisms besides those found in the root nodules of leguminous plants are the nitrogen bacteria which fix atmospheric nitrogen and thereby contribute sufficient quantities of combined nitrogen to the soil. They live on the organic matter in the soil and always need a constant supply of oxygen for their activities. They need time to work up their way. Although the Indian cultivator does not know anything about these bacteria, he knows that a fallow often gives him a good yield. According to Howard 'long fallows are all very well in sparsely populated tracts like Sind, but where the pressure of population is

considerable their duration must be shortened" (1).

Another source from which the soil is enriched in nitrogen is rainfall. It was long contended that the Indian rainfall brought more nitrogen in the form of ammonia and nitric acid to the soil than was brought down at Rothamsted (which was about 4.5lbs. per year). Experiments conducted at Madras and Calcutta definitely proved that the Indian soils did not receive even as much as Rothamsted. Dr. Van Geyzel of Madras showed in 1888 that 4lbs. of nitrogen were received by the soil and that only 2.1lbs. were received the subsequent year. Mr. Bamber's experiment at Calcutta showed that the soil did not receive more than 3.4lbs. of nitrogen annually.⁽²⁾ Although no definite experiments have been done in the U.P. it can be inferred without any fear of opposition that this Province receiving only about two-thirds of the rainfall of Madras or Calcutta receives a smaller supply of nitrogen than either of the places where the experiments were carried out.

Rotations:-

A common rotation practiced by the cultivators of the U.P. is the use of fallows with Rabi in the first year and Kharif in the second year, one of which is usually a

(1) Crop Production in India - A. Howard, 1924, p. 37.

(2) Agricultural Ledger 1898 - No. 2, on the composition of Indian soils. A Note by Dr. J. W. Leather.

leguminous crop, This type of rotation is only followed in poorer fields than average, which cannot endure double cropping. In heavy soils of the eastern districts a very good rotation practiced is paddy in the Kharif and pea in the Rabi of the same year though pea can be substituted by gram (chickpea). This system of cropping works year after year without deteriorating the soil and ^{does} ~~not~~ need irrigation if the rainfall has been properly conserved. In the western districts of Meerut division, where canal water is available, a three years rotation of cotton, sugarcane, fallow, wheat is very popular. It will be interesting to note here that a leguminous crop is not followed by a cereal and, on the other hand, a cereal is followed by a fibre crop. This rotation is only possible on good soils having irrigation facilities as all the crops require watering and are fairly exhausting crops. The residual manure of sugarcane fields coupled with fallow is sufficient for the next wheat crop for which no other manure is applied. Further, cotton roots penetrate deeper and draw their nourishment from the lower layers of soils whereas the two cereals are surface feeders. In this way two different layers of soil are utilized by two types of root systems, the result being uniform exhaustion of soil. The two main points to be followed in crop rotation are that a legume should be followed by a cereal and a deep rooted crop by a shallow rooted

one. As far as possible two similar crops should be avoided, e.g. a tuber should be avoided after a tuber or a fibre after a fibre or a deep-rooted crop after another deep-rooted one. Though to some extent unavoidable a cereal is rotated after a cereal, the cultivator has judiciously put the shallow rooted cereal after a deep rooted one. A type of mixture (of two or three types of seeds) is also sown sometimes as an insurance against the vagaries of weather (1) and also so that the roots of the different seeds can feed uniformly throughout the layer of soil. This type of mixture also affords economy in tillage and keeps the land free of weeds as the whole area of the field is practically covered by the different types of plants.

Superior soils are fully exploited and are invariably subjected to multiple cropping. Water and manure are the two important needs of the Indian cultivator and wherever this condition is fulfilled he can grow his crop. Fields lying just outside the village being the most fertile, undergo extensive cropping. Canal tracts undergo continuous cropping even with little manuring and this lack of manure makes^a/successful system of rotation all the more necessary. The Indian peasant does not understand the underlying principles of rotation but by careful observation and judgment

(1) I. G. of India, Vol. III, 1907, p. 25.



Sugarcane farm near a tide well station.

he knows the best rotation for his own fields, which land will yield to continuous cropping and which will need rest.

Cultivation:-

The cultivation of different crops varies from place to place according to tradition, although the latter may be based on highly scientific principles. Regarding the proper time of sowing and harvesting the cultivators are guided by folk-lore and proverbial sayings.

Early cotton and fodder receive practically no preliminary cultivation. As soon as the Rabi is harvested, one watering is given and the field is ploughed in after the seed has been sown broadcast on the unbroken surface. The reason for such a practice is simple to understand. Early cotton and the irrigated fodder being sown in the middle of May, the evaporation is very great and hence if the fields were to be ploughed after an irrigation it would mean a loss of moisture and a delay of three or four days. Therefore the seed is broadcast just after irrigation and ploughed later to leave the seed at the desired depth. A delay of even one day might prevent germination. Usually with other Kharif crops which are sown at a break in the rain, very little cultivation is given. Sowing immediately after the first fall of rain is the rule as delay would shorten the already short period of growth and the moisture of the first showers might be lost. Hot weather cultivation in May and

June is very important as it helps in opening the soil and thereby initiating the bacterial activities. The most important point is that it prevents run-off, i.e. loss of very necessary moisture and consequent washing away of good and useful soil. If the soil has been thoroughly broken in the hot weather, moisture of the first shower is retained on the field and penetrates into the soil which makes sowing possible immediately after the first showers have been received. Rabi is given a thorough cultivation during the rainy season in the plots that did not grow any Kharif. The clods are crushed by a wooden clod crusher after the cessation of the monsoons. The plots which are meant for Rabi are given a number of ploughings alternated with levelling as this practice conserves moisture and builds up a supply of nitrogen available for the growing plants. The soil is pulverized and brought to a fine tilth before the Rabi sowing.

Agricultural Implements Belonging to a Farmer of 10

Acres:-

On an average one country plough suffices for a plot of 10 acres. It is worked by a pair of bullocks or in some parts (e.g. Bundelkhand) by a pair of he-buffalos. About a quarter of an acre is ploughed in a day of 8 hours, which means that it takes about 40 days to plough the whole plot. The whole plot is never usually utilized in one season, half

of it in each season being the rule. 20 days is therefore the time he needs for giving a ploughing to half the plot. Hot weather and rainy weather cultivation is given in turn to the Rabi fields and in this way the cultivator is able to manage his field. It is only during the sowing time that he experiences difficulties because this is already very short and delay causes bad germination. A wooden clod crusher for levelling and crushing of the clods is required for a farm of 10 acres. Other implements are, one spade or at the most two for digging the soil or making the embankments, and one Kassi (a wooden instrument for making irrigation channels). That is all the agricultural implements and livestock required to make a living. Over and above the two bullocks he might have another one to replace one out of the pair when over-worked. One cow or she-buffalo may also be possessed by him for the preparation of Ghi (clarified butter) which he sells in the market for cash. Occasionally he has one or two she-goats which he keeps for their milk supply, especially as upkeep does not cost him anything, the goat living on any kind of tree leaves. In non-canal districts he has a charsa (bag of leather to raise water). Where intensive farming is practiced one plough and a pair of bullocks is sufficient only for 5 acres. The number of ploughs and cattle increase proportionally with the area.

Agricultural Calendar:-

It is convenient to conclude the chapter on General Agriculture with the agricultural calendar which is generally followed in the Province with slight variations from east to west or north to south.

It is as follows:-

3rd. week of June to 1st.

week of July Kharif sowing.

2nd. week of July to the

end of September Weeding, hoeing and other inter-cultural operations. Rainy weather cultivation of the Rabi fields and also partial harvesting of Kharif.

October - November Remaining Kharif harvest, Rabi sowing and picking of cotton.

December - February Inter-culture operations of the Rabi crop, e.g. weeding, hoeing and irrigation; final picking of cotton and crushing of sugarcane.

March - April Sowing of sugarcane and harvesting of Rabi.

May - Early June Thrashing of the grain and winnowing; sowing of irrigated cotton and irrigated fodder; irrigation given to sugarcane.

Method of preparation of the Cartograms.

The cartograms showing the percentage distribution of crops were made on the basis of statistics given in the "Season and Crop reports of the United Provinces". Two sets of facts were mapped in the cartograms, viz.

(a) the percentage of cultivated to the total land in the district, and (b) the percentage of different crops to the total cultivated land in the district. The average percentage over a varying number of years for different crops were calculated for each district. The district boundaries were put in the map, and these boundaries were supposed to represent a mean percentage between the two adjoining districts e.g. the percentage for a district, say for wheat is 17 and the adjoining district is 23, the boundary between the two districts was supposed to represent a mean percentage of the two districts i.e. 20 per cent. So while drawing the line representing 20 per cent cultivation, this district boundary was taken use of. Wherever more than 50 per cent of the land was cultivated, colours in solid were put in, and two different types of lines represented (a) between 20 and 50 per cent cultivation and (b) below 20 per cent of cultivation.

For/

For wheat, barley, gram, cotton, maize, juar, bajra and rice 10 years' average was taken 1924-5 to 1933-34 and for sugar cane only last three years average was taken as the crop was increasing tremendously in acreage due to protection afforded to Indian sugar by the Government of India. A five years' average was taken for the other less important crops from 1930-31 to 1934-35.

WHEAT (TRITICUM SATIVUM).

Wheat, which is the most important crop of the Province from the acreage point of view, is also very important from the viewpoint of the Department of Agriculture. Many experiments have been carried out with the crop in this Province as well as in the provinces of Punjab, Sindh, N. W. Frontier and Baluchistan. Wheat covers about 21 per cent of the total area under crops, and is the principal food in the western districts especially for the well-to-do class.

A glance at a map showing the distribution of the crop reveals that it is grown in practically all the districts of the U. P. From the distribution point of view four clear regions can be distinguished:-

- a. Upland Region.
- b. The Tarai.
- c. The Plains.
- d. Bundelkhand.

The Upland region includes the districts of Dehra-Dun, Naini-Tal and Almorah Garhwal. Due to the porous nature of the soil and the abundant winter rainfall this tract successfully grows wheat, -~~it being~~ a crop which mainly depends on soil aeration, and irrigation facilities in the winter months. Good drainage does not allow the water to

stand with the result that the soil is well aerated. The heavy rain therefore does not affect the wheat crop as far as drainage is concerned. Drainage is further favoured by the fact that the soil of this tract is not heavy due to its gravelly nature. The Bhabar tract is the characteristic feature of this region which has already been described in the last chapter. The Tarai portion of this tract is specially suitable for rice, but the Bhabar and Doon is pre-eminently suited to the cultivation of wheat. Cattle grazing is another very important industry of the upland region, the farmyard manure produced by the cattle being utilized for the crop production. The richness of the hills in minerals results in a highly fertile silt being carried down by the torrents. Winter rainfall is sufficient to bring the crop to maturity provided mulch formation and other factors governing conservation of soil-water are practised. The government and private canals also help in irrigating the wheat in the winter months. Wheat requires irrigation twice at least in the hilly region though in the alluvial plains very good results have been obtained with only one irrigation. In Naini-Tal the percentage of wheat to the total cropped land is more than 27 whereas in Dehra-Dun it rises as high as 39.1 per cent due to the open nature of the sub-soil in the doons of the last named district.

The Tarai includes the districts of Gorakhpur, Basti,

Gonda, Behraich, Kheri and Pilibhit. This tract though pre-eminantly a rice-growing region is also a heavy producer of wheat. Low-lying lands locally known as Soi or Leti are suited to the cultivation of rice but where there are light loams in the level lands the chief crop is wheat. Good drainage is maintained in these level lands which results in better soil aeration and a correspondingly heavy concentration of wheat. The latter is an ever-increasing crop in this region and so the average for only the last 5 years has been taken in order to make clear to the reader the true state of affairs regarding present-day percentage of this crop. Cultivation increases from east to west, Gorakhpur having only about 20.9 per cent of wheat of the total cropped area whereas at Bahraich it reaches as high as 28.9 per cent. However this tract is not the largest producer because the typical dumat (loam) soil is not in excess of the clay/^{soil}. The clay soils themselves can do well provided the rainfall is below 32" and irrigation facilities exist. Though the sub-soil water in this tract is not far from the/^{surface}~~ground~~, the power required for the lifting of the water does not exist in such abundance as in the western region. The latter prevents it from being one of the largest producers though there is every potentiality and possibility of further increased percentage of the crop as is evidenced from the statistics of the last 5 years.

However it is very important to remember that since rice is the staple crop in this tract the cultivators do not very much care to introduce too much wheat.

The Plains region includes the whole of the plains formed by the Gangetic alluvium. The soils of this tract vary a great deal from east to west. In the east they are mainly the lowland clay soils which are not helped by the heavier rainfall. Thus the whole of the Benares division together with the district of Azamgarh has a percentage of less than 10 of the total cropped area. It is only in Mirzapur that little more than 10 per cent is to be found. As one advances west of this area, clay gives rise to loams, then to light loams and lastly to sandy loams and the rainfall becomes correspondingly less. The result is that the wheat crop gets better aeration and hence there is a heavier production further west. The western plains of the U. P. are colder in the winter months than those in the west but the frosts are not common so that lower temperature is never a matter of serious concern for the cultivators in the plains. To remedy the approaching frosts either irrigation or the burning of rubbish near the fields is practised. The western districts are mainly favourable to the wheat crop because of comparatively low rainfall, the open nature of the soil, and the good irrigation facilities due to the presence of canals. Muzaffarnagar, Saharanpur, Meerut, Moradabad,

Budaun, are the best producers of wheat. The whole area mentioned above is well canalised and the presence of cheap hydro-electric power enables the sub-soil water to be tapped easily. Tube wells worked at Moradabad, Muzaffernagar and Meerut by the hydro-electric power are very successful.

Some 30 years ago Bundelkhand was the area best known for cotton cultivation but today one finds a concentration of wheat, juar and gram, while cotton is practically absent. Burt and Hyder are of the opinion "That the change is largely due to the development of communications and consequent rise in the price of cereals for the production of which these tracts are known to be admirably suited". (1). This added to the variability of monsoons is the reason in the writer's opinion of the decline in cotton and the concentration on wheat, gram and juar. Mar soil due to its friable nature is very well suited to the production of wheat. The rainfall, which is between 30 and 35 inches, also favours the growth of wheat. Soils are retentive of moisture and the tract is protected by canals. Sufficient winter rainfall for the successful growth of wheat is found here so that wheat is the staple food of the people of this region and hence is given great care and attention. "The Bundela cultivator

(1) Burt & Hyder: Bundelkhand Cottons.

is well known for his indolent habits" (1) --- a statement which can be justified by the fact that his main Rabi crop is wheat and gram and his main Kharif is juar. Gram and juar are the crops which require the least amount of care on the part of cultivators, whereas a wheat crop needs considerable attention by the cultivator. He has therefore carefully avoided all the important crops which require constant ^{or hard} labour, e.g. sugarcane, paddy and cotton etc. The people of this region are poverty-stricken because of the agricultural deterioration though the development of communication, the protection of the tract by canals normally would have given an impetus towards better farming and agricultural prosperity, but this has not been the case.

Cultivation:-

The best time for wheat sowing is the middle of October when the rains have stopped. Usually it remains in the field for about 5 months. This crop requires about 60 pounds of seed per acre and is usually sown behind the plough, the number of ploughings depending upon the monsoons. If they are heavy it may need a greater number of ploughings, but if the monsoons are weak the number can be reduced. If there is a long break in the monsoons the land may require to be properly hoed in order to stop evaporation. 3 inches

(1) District Gazetteer Jhansi.

of mulch formation reduces evaporation by as much as 50% while 6 inches is still more effective and 1 inch may prevent evaporation altogether (1). Hot weather cultivation is especially advised for this crop as the pulverizing prevents evaporation to a very great extent as described above. If the soil is allowed to wash out, the fertilizing ingredients are also washed out resulting in a poor soil and hence a reduced crop yield. If attention is paid to these factors together with the maintenance of a surface drainage wheat will require very little irrigation even as a final crop. Ploughing should preferably be done by a soil-turning plough and sowing should be done by a country or Desi plough. The greater the soil-turning capacity the better the mulch formation and hence the smaller the evaporation. Wet soils cannot be ploughed by heavy ploughs the only alternative therefore being the country plough. Land broken with the country plough will absorb a considerable amount of moisture but it will not be so effective in initiating the bacterial changes, which is an important factor for an increased yield (2).

The Lever harrow is well suited for the formation of a mulch of 2 inches by a single cross cultivation in the

(1) Improvement of Indian Wheat - A. Howard and Gabrielle L. C. Howard.

(2) Russell & Hutchinson: Journal of Agric. Science, Vol. III, p. 14.

with

Gangetic alluvium. This is an implement ~~in~~ which the slopes of the tines can be altered by a lever. It can be driven over the young wheat without any serious damage to the crop and at the same time the surface crusts can be broken and the weeds in the wet region uprooted. Afterwards the late crusts can be broken and also the weeds removed with very little damage by an implement known as the Brantford Weeder until the crop has formed an ear. (1).

Irrigation depends mainly upon the conserved moisture in the soil at the sowing time as well as after it. Well conserved moisture in a well-prepared seed bed with a good average winter rainfall may need only one or even no irrigation. Clarke at Shahjahanpore obtained as much as 36.5 maunds of wheat per acre in an area of 3.4 acres after a crop of canes (2).

The writer during his tour in the Province found that on an average two irrigations are needed in the eastern districts with a rainfall of more than 32 inches and about 3 irrigations are needed in western districts with a rainfall of less than 32 inches. The Department of Agriculture recommends that the least possible number of irrigations be

(1) Pusa Bulletin No. 118, p. 5.

(2) Improvement of Indian Wheat -- Albert Howard & Gabrielle L. C. Howard.

applied to this crop and that these should be carried out as late as possible otherwise the crop begins to show all the signs of insufficient soil aeration, i.e. a high proportion of straw to grains, and poor development of grain as well as colour of chaff (1). Slow ripening and poor development of the roots cannot utilize the winter rainfall and draught results (2). To a very marked degree this was evident in case of the Punjab wheats (3). The watering should therefore be done shortly after the crops head out, otherwise there is always a risk of crop lodging which is so common in the western districts due to strong winds in the month of March. The application of water should be carefully adjusted so that both the dangers of logging and drying can be avoided.

With regard to varieties, P.4 is specially suited to the Bundelkhand area, P.12 to the alluvium in the U. P.. P.52 to the eastern districts of the U. P., C. 13 and P.54 to the parts of the U. P. where bearded wheat is essential. Results obtained with P.12 and P.4 were summed up by the Director of Agriculture in 1918 in the following words:- "When grown under the same conditions as native or Desi wheat the improved varieties do give a higher yield. The difference

(1) Improvement of Indian Wheat -- A. Howard and Gabrielle L. C. Howard.

(2) Pusa Bulletin No. 118.

(3) Pusa Bulletin No. 31, p. 3.

is from 3 to 4 maunds per acre". (1).

S. K. Gurtu (2) the irrigation member of the Board of Revenue in the Irrigation Act of Gwalior has fixed eight annas per Bigha for watering but the Royal Agricultural Commission has suggested that the system of irrigation in India should be in terms of volume instead of crop, to stop the injudicious application of water to the wheat crop.

Wheat is a very soil-exhausting crop especially with regard to nitrogen content and therefore rotation with a leguminous crop is very desirable to bring back the soil to its original state. The writer has seen fields being green manured before Rabi preparations for wheat sowing. Sannhemp is sown with the rains and after about 2 months it reaches a height of 3 to 4 feet when it is ploughed down by a soil inverting plough and allowed to rot in the field which after six weeks forms a very good green manure for the wheat. Leather (3) says that "one of the dangers of growing a green crop immediately before wheat is that there is a liability to the soil moisture becoming dissipated at least in the surface layers to such an extent that the green material has no opportunity of becoming thoroughly decomposed before the wheat

(1) The Report of the Administration of the Department of Agriculture of the U. P. for the year ending 30th June 1918, p. 4.

(2) A.J.I. Vol. XIX, July 1919.

(3) Experiments at the Cawnpore Farm on the Growth of Wheat (a) with green manuring and (b) in rotation with leguminous crops -- Dr. J. W. Leather.

is sown. Indeed it may even dry the surface soil to such an extent that the loss of soil moisture must be accounted greater than the plant food but the average figure shows the decided increase of yield from sann-hemp". Regarding rotation he is of ~~the~~ opinion that in the majority of cases an increased yield has resulted but this is all one may venture to say. Dr. Voelcker refers to green manuring in paragraph 129 of his Report on Agriculture and recommends it as a practice which might profitably be more widely employed by the Indian cultivator (1). Even if a part of the holding were manured every year by a leguminous crop the productive capacity of the soil would gradually rise giving place to intensive instead of extensive cultivation and thus going a step forward towards the agricultural prosperity of the rural masses.

Irrigation channels, which should be 10ft. square for a successful even distribution of water to the field, should be made before sowing (2). An irrigated crop requires a higher seed rate than a dry crop.

The attack of rust is not so common as in the English wheats doubtless due to the greater dryness of the climate.

(1) Report on the Improvement of Indian Agriculture -- Dr. Voelcker.

(2) A text book on Indian Agriculture -- J. Mollison, Vol. III: Field and Garden Crop of the Bombay Presidency.

The disease is predominant in Meerut and Rohilkhand divisions due to regular winter rains and consequent mists and cloudy days in the months of December and January. It is practically absent from the central districts and Bundelkhand tract. This disease enters the plant tissues and forms orange coloured spores which when ripe burst through the plant skin in longitudinal fissures sprinkling the leaves with a powder. These bodies grow into clusters with the ripening of the wheat crop and appear a black spot to the naked eye. It is at this stage that the fungus is known to 'puccinia'. No remedy has so far been successful in the attack except the breeding of rust resistant varieties e.g. P.12, P.4.

Ergot also causes infection to ^{the} wheat crop by filling the grains with a greasy black powder and leaving the grain externally in a perfectly healthy condition. This disease is not so common in the Indian wheats. More common is the smut disease of wheat, but this can be checked by dipping the seeds before sowing ^{into} ~~a~~ $\frac{1}{2}$ per cent solution of sulphate of copper for 5 minutes and then drying the seeds in the sun.

BARLEY (HORDEUM VULGARE).

Barley is an important Rabi crop of this Province, next in importance only to wheat. It is the staple food of the poor people in the western as well as in the southern districts of the Province. The main use of barley is as an article of food, but the manufacture of alcohol from barley is also very important.

From the distribution map two regions of production can clearly be discerned (a) the eastern plains and (b) the western canal tract.

A study of the climatic and soil requirements is necessary to understand the distribution of this crop. It requires soils of light nature, the upland portion of the plains is therefore the suitable tract for barley growing. It is very rarely irrigated, and one irrigation is often given in the west. When sown intermixed with wheat, it is irrigated only when wheat fields need water due to either failure of winter rains or injudicious cropping or improper conservation of moisture. The most important factor governing the production of barley in the eastern plains' region is that wheat as a Rabi crop does not agree with the conditions in the east. Barley is the next important ^{Rabi} crop, and is not as sensitive as wheat, hence it has become the main Rabi crop for the eastern districts. Jaunpur has as much as 29.6 per

cent of the total cropped land. Azamgarh has over 26 per cent and Sultanpur has a little more than 24 per cent.

Coming to the western canal tract, the chief concentration is noticed at Bulandshar and Aligarh, the former grows 17.6 per cent of the total cropped land and the latter over 18 per cent. The western tract being mainly a wheat growing region has comparatively a lower percentage of barley production. If the winter rains have been good the crop is not given any irrigation, otherwise one watering may be given when it is grown with wheat. Irrigation and cultivation is given just like wheat. The main attention of the cultivators during Rabi is concentrated on wheat and not crops like barley because the former is expected to pay the cultivators more. Lighter loams are given to barley cultivation. Manured soils are utilized for wheat whereas the unmanured land is given to barley cultivation. In the western tract barley is a secondary Rabi crop, only the lands not suited to wheat are given for barley cultivation. It is not grown in the Tarai and Bundelkhand because of the abundance of clay soil of a heavy nature.

After explaining the distribution it will not be out of place to give a brief description of the methods of cultivation of barley practised in this Province.

Regarding cultivation it is practically similar to that of wheat except that it is sown earlier than wheat and does not need so many ploughings as wheat, as this is chiefly

grown on light soils. It is very rarely manured. It is a surface feeder, ~~xxxxxx~~ the roots are weak and ~~can~~ ^{do} not penetrate deep into the soil. It exhausts the soil and does not leave any crop residue. It is believed by Ram Parshad (1) that barley exhausts the soil sooner than wheat. It is rarely sown alone and is usually intermixed with wheat, gram or pea. The intermixture depends on the fertility of the soil. Barha (2) soils are employed for the cultivation of wheat but the soils having a poorer amount of residual manure are sown mixed with barley. It is mainly the fertility which determines the extent of production of this crop. Barley is usually grown on the lands which had a Kharif harvest. Cultivation usually depends on the other crop with which it is intermixed. As it is grown on very light soils it does not need a high pulverization of seed bed and only a therefore/reduced number of ploughings. At an average four ^{the number} ploughings are given, of course/depending on weather conditions. In Rohilkhand even ten ploughings are not uncommon. Sowing is usually done in the first week of October - later than gram but earlier than wheat. Failure of September rains causes great difficulties for sowing of

(1) Ram Parshad: A Note on the Barley in U. P.

(2) The land surrounding the village dwellings or scattered village hamlets, getting the biggest share of night-soil and other manures, is locally known as Barha.

barley as the ground becomes too dry for proper germination of seeds. September is the most suitable month for the preparation of the seed bed. Dry Septembers need irrigation and ploughing before sowing.

About one maund of seed per acre is needed and is sown behind the plough. After sowing irrigation channels are made in the fields. In the western tract rarely any irrigation is given because of a fairly certain winter rainfall and in the eastern plains it needs at an average one irrigation. No topping and weeding is practiced as in the Punjab (1). Harvesting is done by means of bullock power as in the case of wheat or by threshers if cheap electrical power is available. Rains in the month of March or beginning of April at the harvesting season cause great damage to all the Rabi crops and especially to wheat and barley.

There are mainly two types of seeds (a) two rowed variety (*Hordeum Distichum*) (b) six rowed variety (*Hordeum Hexastichum*). The six rowed variety is most commonly grown in this Province, the double variety is grown in the northern districts if at all. There is another interesting variety of barley, the naked one (*H. Gymnostichum*). This may be white, blue or red grained. This is not an indigenous variety and seems to ^{have been} introduced from other places and

(1) Duthy & Fuller: Field and Garden Crops of U. P.

usually is not grown in the Province.

After giving a brief outline of the methods of cultivation the description of barley will remain incomplete without the knowledge of the process of malting as practiced in the Indian breweries.

Barley is first of all soaked in water and allowed to germinate under favourable temperature until the ferment diastase is properly developed, for which it is necessary that the rootlets be $\frac{2}{3}$ rd. the length of the grain. Germinated barley is then subjected to drying process in a kiln, after which the grains are ground and water added to it to extract the starch and the diastase. It is then subjected to a temperature of 140°F . by adding hot water solution to it. After a short interval the starch is converted into sugar by the ferment. Yeast is added to the sugar solution and when fermentation is complete, alcohol is separated by means of brewing. The process of malting and brewing requires a good deal of experience as the solutions have to pass through a number of critical temperatures which give the proper colour and taste to the alcohol.

For brewing purposes the grains should be thick, of uniform colour, and even size. They should have a sweet odour. Broken bits cause the liquid to be mouldy which may cause infection to the grains. Brewers prefer fat grains because of greater starch percentage in spite of smaller grains having greater diastatic activity. Mealy grains are preferred over stealy grains.

GRAM (CICER ARIETINUM)

Gram is a leguminous pulse, used by all classes of people as a vegetable as well as a pulse, in the same way as the garbanzos ^{is} ~~are~~ used in Spain. It is consumed raw as well as in a boiled state, but the main use of gram is as a feeding stuff ~~for~~ the horses and cattle (mainly for horses). It also makes a kind of flour which is consumed occasionally by the poorer class of people. It is not a very paying crop but has the special advantage of enriching the soil in nitrogen content. It is ~~not~~ usually sown/^{not} alone, but mixed with either wheat or barley.

A glance into the distribution map brings forth mainly three regions of production.

- a. The western plains.
- b. Oudh including the divisions of Lucknow and Fyzabad, and the districts of Allahabad and Fatehpur.
- c. Bundelkhand.

In the western plains it grows in Meerut, Agra and Rohilkhand divisions. Any type of soil satisfies this crop - from the heaviest clay to the lightest loam. In Rohilkhand it is usually grown as a second crop to early rice. In Meerut and Agra divisions it is usually sown mixed with either wheat or barley. Generally it is grown on the poor soils because all rich Rabi lands are reserved for wheat.

The crop does not require irrigation ~~and is fairly secure~~ where winter rains are regular and certain. A mixture of barley and gram is usually irrigated once. When it is mixed with wheat the cultivation mainly depends on the latter. It remains in the field a little more than six months ~~and does not mind the prevailing heat during the sowing time.~~ Regular winter rainfall and abundance of poor soils are the chief reasons for the concentration of this crop in the western districts. Agra and Muttra have the greatest concentration probably because they are full of poor soils. Agra has over 25 per cent of gram to the total cropped land.

Coming to the second region of distribution one finds that the main concentration is at Fatehpur which has over 28 per cent of the total cropped land. The next largest concentration is over 25 per cent at Barabanki. It can be seen that from Fatehpur eastwards the crop diminishes in percentage, because east of Fatehpur the winter rains are not very prominent. In Oudh as well it is grown as a second crop to early rice. A rotation of early paddy and gram, that is two crops in one year, contribute a great deal towards the agricultural prosperity of Oudh peasantry. Such a rotation of a cereal followed by a legume retains the soil fertility and can be safely recommended to the cultivator.. The rainfall in this tract varies from 35 to 40 inches and

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any deterioration to the land.

The Department of Agriculture of the U.P. has given for the use of the cultivators some improved seeds e.g. P.25, P.17, P.18, P6B, and improved Partabgarh (1). Regarding cultivation it can be said that these do not need a highly pulverised but a deep seed bed. They are practically never manured and do well on heavier soils. They are sown behind the plough at a rate of 80 to 100 pounds of seeds per acre in the dry western districts but broadcast with the same seed rate in the Rohilkhand and Oudh. In Bareilly it is common to broadcast the seeds in an uncultivated field after which the field is ploughed (2).

A mixture of wheat and gram forms the staple Rabi of Bundelkhand. A mixture of gram-barley is irrigated once, in the usual course, but the number of irrigations depends mainly on the weather conditions. If it has been a dry year or the winter rains have not come at the opportune moment, more irrigations than one may be needed. A very common practice is to cut back the plants before they flower by picking off the tops of the shoots which are much relished as a vegetable, the flavour being probably enhanced

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- (1) Studies in Agricultural Improvements of the U.P. by
C. Mayadas.
- (2) Duthy & Fuller: Field and Garden Crops of the U.P.

by the exundation of oxalic acid by the leaves. This is a curious property of the leaves of this crop. The topping also increases the out-turn and renders the plant strong. Three main varieties are recognized by the native cultivators.

a. White or more commonly known as the Cabuli variety. This is the one which resembles the Spanish garbanzos and is a favourite vegetable dish in India.

b. Brownish red variety.

c. The black variety.

The last two varieties are mainly used as ~~the~~ pulses or feeding stuff for ~~the~~ horses.

Harvesting is done in the same way as wheat or barley. Yield is greatest in tracts of winter rainfall and heavy soils. An irrigated land yields about 12 maunds of gram, 14 maunds of gram-barley mixture and 13 maunds of gram-wheat mixture. Straw is about $1\frac{1}{2}$ times the weight of grains and husk and ~~is~~ ^{is} very palatable to cattle and therefore is mixed with many unpalatable fodders.

RICE CROP IN THE U. P. (ORYZA SATIVA)

Rice, one of the most important crops in the U. P., is the staple food of about 75 per cent of its population of the poor in the east and the Tarai districts while it occupies about 20 per cent of the total area under crops.

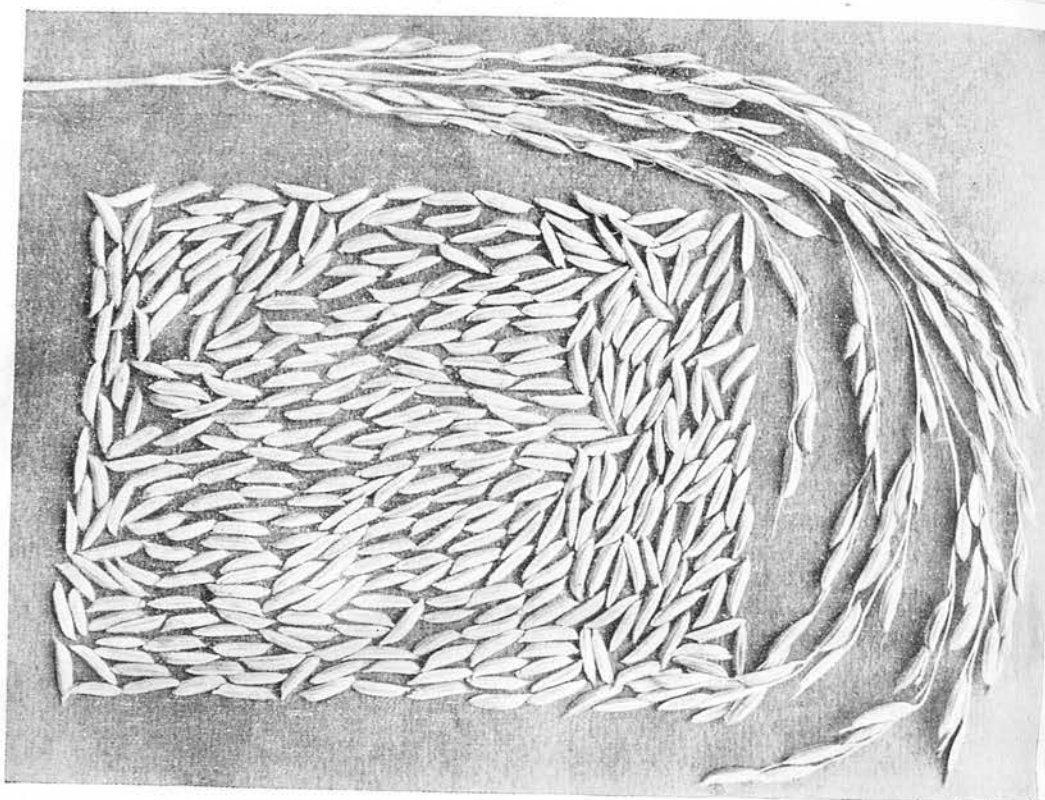
The percentage distribution map of this crop shows three prominent areas of distribution (a) Upland Valley (b) The Plains (c) The Tarai.

(a) The Upland Valley includes the districts of Dehradun, Almora, Garhwal and Nainital. Here one comes across the terraced cultivation of rice even as high as 5,000 feet above sea level. This is the tract of land which produces one of the finest varieties of rice known as the Dehradun Bansmati which is prized for its quality and is usually served at the tables of the rich.

The soil of this tract, as has already been referred in the last chapter, is composed of weathered rock, porous and gravelly in nature. This added with sufficient amount of solid matter brought down by hilly streams gives the fertilizing ingredients to the soil of this tract. The Duns again are renowned for their fertility and are the chief centres for the rice cultivation in this tract. A good drainage all round also adds to the fecundity of the soil. An average the rainfall is over 60 inches. Irrigation is only

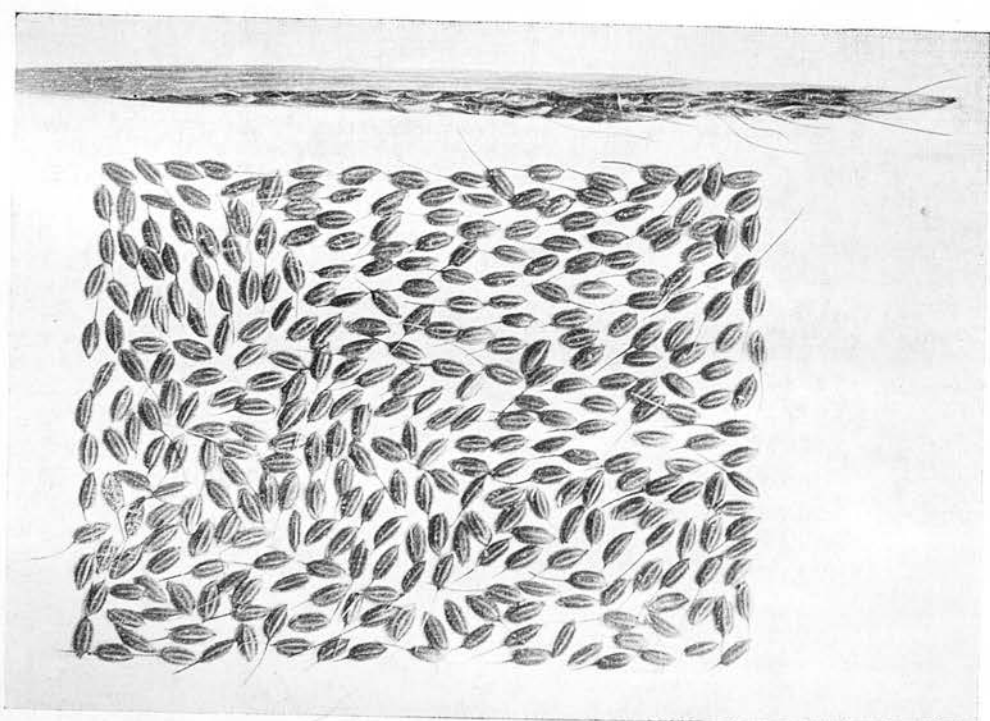
effected by the hill torrents though to a certain extent by the government and private canals in Kumaun. As regards distribution Dehradun has over 24 per cent of paddy cultivation to the total cropped land.

(b) The Plain's region is the central part of the Province bounded by the rivers Ghagra and Jumna stretching from Saharanpur to Ballia. West of the 32 inches isohyet, passing through /roughly/ Cawnpore, less than 10 per cent of rice to the total cropped area is grown. It is only in places with more than 32 inches of rain that this crop can be economically grown. This plain region is a dead level plain with poor drainage. It is in such areas of poor drainage having a clay soil that rice crop is successfully grown. In the plain three types of soil are to be found, sandy loam in the higher grounds, light loam in the level land and clay in the depressions. The last is the most suitable for rice cultivation. Irrigation is usually done by canals in the western districts and wells and artificial reservoirs in the eastern. Water is lifted by mechanical arrangements such as Egyptian screw, or Persian wheel or Dhekli. Innumerable varieties of rice exist but generally speaking the early varieties do well in the western districts while the late varieties in the eastern. In the plains area Azamgarh has a little over 40 per cent of paddy cultivation to the total cropped area, Fyzabad over 39, Sultanpur over 38 and Benares 32.



1. *Basmali* (fine).

Typical examples of fine (transplanted) and coarse (broadcasted) rices of the United Provinces.



2. *Sethi* (coarse).

(c) The Tarai - this tract stretches from Pilibhit to Gorakhpur on the northern boundary of the Province along the foot-hills of the Himalayas. Cultivation increases from west to east, so much so that at Basti it is over 51 per cent while at Pilibhit it falls to about 34.5 per cent.

The Tarai mostly comprises clay with some white soil at Gorakhpur and Basti which is prized for sugarcane cultivation. Fields in this tract are surrounded by bunds to hold rain water to be utilized at the time of drought. Humidity in the soil is always great, due to heavy rainfall which is between 40 and 50 inches and also due to presence of forests in the northern part of the district. Sub-soil water is at a depth of about 10 to 12 feet and facilitates well irrigation. This tract has a deficient drainage due to poor level. These conditions e.g. high humidity and rainfall, clay soils, bunding of the fields, poor drainage and nearness of the sub-soil water, all render this tract suitable for paddy cultivation and especially for the late varieties. Practice has shown that 6 inches of standing water has a beneficial effect on this crop.

After discussing the general distribution and requirements of this crop it is necessary to give a detailed description of the cultivation prevalent in this Province.

Mainly two methods of cultivation are practiced in this Province (a) broadcasted (b) transplanted.

Broadcasted is the early variety and is known as Bhadoin or Kuari after the name of the Hindustani months in which the crop is harvested. One of the broadcasted varieties is known as Sathi (which ripens in 60 days). West of Cawnpore or below the isohyet of 32 the crop is mainly broadcasted though some transplanted varieties also grow in this area. About 66 per cent or roughly two-thirds is the broadcasted rice.*

About 80 pounds of seed is sown per acre just after the first showers, and if the monsoons break early the maximum area is sown and if the rains are delayed the area is reduced so that the area under broadcasted rice is dependent upon the monsoons. In the eastern districts sometimes the seeds ^{are} sown before the monsoons and ~~they~~ germinate after the rains set in. Thus the cultivators are able to save time. After the germination the young seedlings need no care. It is only in cases of long withdrawal of monsoons that the crop needs attention and has to be irrigated. In cases of excessive rains the fields become weedy. They should be hoed when the plants are about a foot high to remove the weedy growth. By this method of interculture 5 to 10 per cent of the plants are lost and this method resembles Beushaning in Orissa (1). Inter-culture helps

* Season and Crop Report 1934.

(1) Basu, S.K.: Green Manuring of Broadcasted Paddy in Orissa Agric.Jnl.India, Vol.XVI, 1921, p. 689.

the tilling of the plants and keeps the land free from the growth of weeds. Paddy is either sown alone or mixed in the eastern districts with Arhar (*Cajanus Indicus*), Khesari (*Lathyrus Sativus*), Kodon (*Paspalum Scrobiculatum*) or Juar (*Sorghum vulgare*). This is practiced as a safeguard against the failure of monsoons. In the event of drought the rice crop will not be favourable but the other crop which is not very exacting in water requirements will grow well.

The crop ripens in August or September when it is cut and thrashed. The varieties harvested are of a coarser type and are, therefore, consumed by the poorer classes of people. Out-turn is decidedly lower than that of the transplanted variety. The average out-turn of paddy is from 800 to 1,000 pounds per acre; about a quarter of this being the weight of the husk.

The rotation practiced in the east is paddy-pea, and in the west paddy-gram but in any case paddy must be followed by a legume. Double cropping is the chief reason for the extension of early varieties in the U. P.

Transplanted is locally known as Aghani or Jarhan, the name derived from the month in which it is harvested. This takes longer to ripen than the broadcasted variety and hence named as the late variety in the Season and Crop Report. About 33.7 per cent of the total rice is this variety.

20 to 25 pounds of seed is required per acre. The seed

is sown in a heavily manured and well cultivated nursery and allowed to grow there for about 40 days. When the seedlings become 1 to $1\frac{1}{2}$ feet high they are transplanted to a well prepared field. The field is ploughed and puddled before receiving the seedlings and about 6 inches of standing water is allowed to remain in the field. The best time for transplanting the seedlings is the month of July. Instead of transplantation, sprouted seeds are sown broadcast in certain districts such as Dehradun, Pilibhit and Kheri to save labour and time. This system gives a good yield provided the rains are timely. When the rains stop or there happens to be a long gap at the end of July or beginning of August, transplantation is delayed, thereby losing a part of the growing time. Deficiency or cessation of rains in the month of September causes a serious damage to the crop except where irrigation facilities are available either in the form of canals, wells or reservoirs. Sowing and transplanting are done a little later in the eastern districts due to longer stay of the monsoons in the east. Usually the crop is harvested by the end of November. Other operations differ due to local traditions. Out-turn is usually between 1,200 and 1,400 pounds per acre of unhusked rice. The rice is of better quality, and forms an important article of export from the rice exporting centres e.g. Dehradun, Gorakhpur and Benares.

There is a marked increase in the yield of the transplanted variety. This is of a better quality and affords a saving in the seed rate whereas the disadvantages are that it needs more labour and that too all at one time, e.g. just at the time of transplantation. Besides the crop stands for a longer time in the field and needs opportune supply of irrigation.

There are two more types of rice having a little difference in their method of cultivation which need a passing mention. One is known as the Jethi, the name here again is derived from the month in which it is harvested. This is a Zaid or an intermediate crop between the Khari and the Rabi. It is grown in the slimy lands and beds of the lakes having not more than 6 to 8 inches of water. It is chiefly grown in a nursery in the month of December or January, transplanted in February and finally harvested in the month of May. It is a poor class of rice and ill-favoured in spite of the fact that it is transplanted. The other one is known as Bhenta and is chiefly grown in Rohilkhand. It is usually harvested before the Rabi, and does very well in standing water. The out-turn is good but very uncertain. This has a special method of harvesting, only about $1\frac{1}{2}$ feet is cut from the ears and the remaining stalk is either allowed to rot in the field or burnt and acts as manure.

There are two common methods of husking the rice (a) by

wetting the unhusked rice in water for about 30 hours and then allowing it to dry for about 6 hours in a frying pan and for 2 days in the sun, after which it is pounded in a wooden mortar and is ready for use. (b) The second method consists of pounding in a mortar without undergoing the wetting and drying process. This sort of husked rice is known as Sela rice. The first method of husking is better because very little quantity of rice is broken. (c) Rice hullers are also used these days for husking paddy in areas where it is grown on a large scale.

The insect pest which causes the greatest damage to this crop is Gundhi (*Leptocorisa Vericornis*). The most usual time for their multiplication is from middle of August to middle of October and therefore they attack mostly the early varieties. Their distribution is mainly favoured in the east and is predominant in the Tarai districts of Bahraich, Gonda, Basti and Gorakhpur. This shows that they have a special relation with soil and climate. They probably prefer very humid climate and clay soil and hence their distribution in these areas. The matter is yet under the investigation of the Agricultural Department.

The control lies in netting the insects and killing them, though this method is valuable only in reducing the number. Application of powdered cake of Neem (*Azadirachta Indica*) is found successful in lessening the attack.

Another method suggested by Lefroy (1) is to introduce Blue Beetle (*Cincindela Sexpunctata*) which feeds upon the Gundhi bug. This method has been very successful in Bengal.

The experiments of the Department of Agriculture have proved that ploughing after the crop is removed and hot weather cultivation increases the yield and reduces the weeds and insect pests. The Department has also proved that occasional drying gives very good results in the form of increased yields and reduced vegetative growth. They have also found green-manuring with sunhemp (*crotonaria juncea*) to be the most effective of all the manures used (2).

(1) Lefroy, M.M.: Indian Insect Pests, p. 118.

(2) Note on Rice Crop in the U. P.

MAIZE (ZEA MAYS)

Maize is not the staple food of the Province. The crop is harvested at the end of August and the next six months the cultivators of the western tract eat maize supplemented by barley, wheat and gram flour.

The two main centres of production ~~can be distinguished~~^{are} (a) the western canal tract (b) the Terai districts of Gonda, Bahraich and Kheri.

The main concentration on the western canal tract is at Bulandshar which takes the lead of 12.8 per cent of maize cultivation to the total cropped land, and Aligarh stands next having about 9.7 per cent. The soil requirements of this crop are from light clay to light loam. It is not a surface feeder like barley, maize roots penetrate deep into the soil and it is an exhausting crop. The greater the manure and irrigation the better is the production. Lighter soils, abundance of farmyard-manure and greater facilities for irrigation favour the growth of maize and hence the concentration in the western districts. The district of Farrukhabad has a special rotation of three crops in one year, maize, potato and tobacco. This rotation has gone a long way towards the agricultural prosperity of that district (1). In other western districts maize is usually rotated with wheat.

(1) District Gazetteer, Farrukhabad.

The main Kharif crop of the next tract (Tarai dt.) is paddy which utilizes all the heavier type of soils. The light clays and the loams are used for maize cultivation. Besides Kheri and Bahraich being breeding tracts they are in constant demand for fodder and good grazing land, hence the concentration in Tarai districts. From the statistics it is clear that Chari (*Andropogon Sorghum*) is grown to a very little extent, (below one per cent in the Gonda and Bahraich districts and a little over one per cent in the Kheri district) as the soil and water conditions do not allow the growth of the latter fodder. Maize has an additional advantage of being ready as a fodder crop in only two months and that is why it is favoured by the cultivators. The crop leaves the soil in good time for the Rabi preparations to be made. The stalk of maize makes quite a good fodder for the cattle though it is not so much relished as the Chari still in absence of any other good fodder maize is a good substitute for the cattle of this locality. Bahraich has the biggest concentration of about 28.3 per cent of maize to the total cropped land and Gonda has a little more than 19 per cent.

After discussing the distribution it is necessary to give a brief outline of the practices of cultivation in vogue in this Province and the scientific principles on which they are based. Maize as has already been discussed requires from light clay to light loam but the medium loam is the ideal for its growth. It can ~~not~~ stand ^{a large} ~~large~~ amount of rainfall. East of Cawnpore less

than 5 per cent of the total cropped land in each district is under maize whereas in the western districts it is between 5 and 13 per cent. Two or three irrigations are needed during long gaps of the monsoons. Even three weeks gap will not effect the crop if hoeing has been properly done to conserve the soil moisture and the sunshine has not been very strong, but 10 days gap might effect the crop if the previous fall had not been sufficient or a strong sunshine had prevailed and consumed the surface moisture by capillary action. It is the cultivators own judgment to adjust irrigation to such a nicety that just sufficient and no more water is applied to the fields, as just a little extra water will cause water logging, resulting in a partial draught or a complete destruction of the crop.

If, maize can be sown in the middle of May with an inundation and ploughing of the fields, it usually fetches a good price as the cobs are purchased at a higher price at the earlier season near the big markets. The later the crop, the less the cash value the crop would fetch. Where it is not needed for cobs it should be sown with the break of monsoons. Ten to twelve pounds of seed is sown per acre, sowing is done behind the plough. Subbiah (1) suggests the dibbling of the seeds by a hand hoe. Three or four seeds should be dibbled in a hole and the distance should be kept one foot from plant to plant and two feet from row

(1) P. B. Subbiah: Cultivation of Maize at the Cawnpore Experimental Station.

to row. To get this distance he suggests to keep the distance $1\frac{1}{2}$ ft. by 9 ins. as all seeds will not germinate and the desired effect of the distance will be obtained.

Maize requires a well prepared deep seed-bed having a rich and well manured soil. It requires a heavy dressing of farmyard manure as it is a good feeder and a good producer. Digging and hoeing gives good results in the form of increased out-turn. The crop having a poor development of grains or showing no signs of promise are cut and fed to the cattle. The average out-turn is 12 to 15 maunds per acre though 30 maunds yield has also been obtained at the Cawnpore experimental farm. There are two varieties (a) The American variety (b) The country variety. The American variety does well for the Province as a whole wherever the crop is grown. The country variety has again two subdivisions (a) deep yellow country maize which does well for the central districts eg. Cawnpore, Lucknow and Unao, (b) light yellow country maize also known as Jaunpur variety which does well in the Jaunpur district and the whole of the Meerut division.

Watching is the most important item for the successful production of this crop "the ringing and not unmusical cries of the watchers in early September mornings are always pleasantly associated with the return of cold weather". (1)

(1) Duthy & Fuller: Field and Crops of the U. P.

JUAR. (ANDROPOGON SORGHUM)

A careful glance at the map of the percentage distribution of Juar crop in the U. P. will reveal that the heaviest concentration is in the Bundelkhand Division (excluding Jalaun dt.) and Cawnpore, Fatehpur and Muttra districts. In all these places the percentage of Juar to the total cropped area is over 15.

Before fathoming any reasons for the heavy concentration in the aforesaid tracts it is necessary to know the requirements of this crop.

It is a cereal which is not very exacting in the soil requirements nor is it so fastidious to water, a little extra or a little less than the normal does not affect it to a very great extent. In practice this crop is grown on comparatively poor type of soils and as a rule is rarely irrigated. This crop is sown just at the beginning of the rains so that the chances are that the crop may suffer from water logging but in no way from drought unless the year is particularly dry and rainless. In the years of drought even, this crop is never irrigated as the monsoons never completely fail and the amount of rainfall in such years is enough to keep the crop growing. In very dry years Juar does not flourish so well although it can stand the drought. In the U.P. though the variability of rainfall is great in some places but still a complete withdrawal of monsoons is not very

common therefore Juar grows without much difficulty. This crop in the U. P. is not a cash crop; this is mainly a fodder crop therefore much attention is not given to ~~this/crop~~^{it}. The stems of Juar are chopped into small pieces and fed to the cattle hence the cultivators do not want to give a lot of energy for the ripening of the grains, the succulent stems are harvested and fed to the cattle before the grains start growing as otherwise it is a waste of soil food unless of course the crop is grown for grains. It is usually sown alone but sometimes it is intermixed with Bajra or Arhar; when it is sown with Bajra cobs are cut away first and later the stems are cut which are fed to the cattle but when it is intermixed with Arhar, Juar stems are cut and Arhar is left standing in the field for another 4 or 5 months to ripen. Intermixing with Arhar takes place in the poorer type of soils which cannot be utilized for Rabi purposes. The idea of intermixture is that the leguminous Arhar may improve the nitrogen contents of the soil by the help of nitrifying bacteria (1) present in the nodules and thus the soil might be used for other crops without the application of nitrogenous manures or by adding very little if at all. Juar crop can successfully be grown on the soil wash having a central rock formation. It is not at all essential to grow Juar crop in the alluvial formations. Being a poorer cereal it can stand any

(1) Voelcker —
Report on the Improvement of Indian Agriculture, p. 46.

type of soil.

Practically all the points have been discussed regarding this crop. It now becomes simple enough to understand the influence of environment on the growth and distribution of this crop.

The predominance of the black/^{and stiff} soil ~~mostly in the Bundelkhand Division~~

(1) in the Bundelkhand Division ~~is not a very good soil for this crop~~

~~which~~ does very well for a crop like this. As has already been explained the soil of this Division does not do very well for other crops e.g. rice, cotton, the latter being very susceptible to water logging but suits the requirements of this crop.

From the general survey one could very well emphasize the possibility of the extension of Juar cultivation in the east and the north-east of the Province but by just studying a little of the economic conditions of the place one will be convinced of the fact that the cultivator cannot afford to utilize the land for a fodder crop like this when he ^{can} ~~could~~ easily get a better return by other Kharif crops e.g. paddy. Even the broadcasted paddy gives him a better return than Juar. Hence the concentration is not to be found either in the east or in the north-east but in the Trans-Jumna Tract especially in the Bundelkhand Division.

Muttra district has a concentration of more than 18 per cent of Juar to the total cultivated area, because it is a cattle breeding centre and hence is always in demand of fodder and grazing land. Though some grazing land is available on the Jumna Khadar still some fodder is always needed. The loams are usually sown with Juar in the Kharif for green fodder which in the Rabi is utilized for wheat. Muttra has ^{nearly} ~~probably~~ the least amount of rainfall in the Province but still it is sufficient for a green fodder like this. Only in cases of long withdrawals of monsoons and long intervals or an unusually dry year ~~that~~ the crop is irrigated to save the ravages of fodder famine.

After having discussed the distribution, the agricultural practices prevalent in the Juar areas are to be studied. It is a crop grown both for grains and fodder. The main utility is that it is the best green fodder available in the Province for the cattle production and breeding. There are two varieties of seeds (a) white and (b) red. The former is superior as fodder and also gives better quality grains than the latter. Morphologically three varieties may be noticed (a) double seeded having two grains in one husk (b) dwarf variety which is mainly grown in the Allahabad district and (c) Chahcha which is completely covered in the husk and therefore suffers the least from the depredations of birds. The last variety is mainly grown at Cawnpore. Its value as a green fodder may be estimated from the analysis made by Professor Voelcker (1) in which

(1) Duthy & Fuller: Field and Garden Crops of the U. P.

nutritive qualities are compared with those of turnips:-

<u>Ingredients</u>	<u>Chari</u>	<u>Turnips</u>
Water	85.17	90.43
Flesh forming matters	2.55	1.04
Fatty and heat producing matters.	11.14	7.89
Inorganic matters.	1.14	0.64

Ten to twelve pounds of seeds for grain and 20 to 25 pounds of seeds for fodder ^{are} broadcast per acre and then ploughed. It is usually sown after cotton. It is irrigated only when sown in the middle of May for fodder or if it happens to be an extremely dry year with long breaks between two falls. Weeding by driving a plough between the lines seems to give a beneficial effect to the crop. When sown for fodder in May it leaves the field in the opportune moment for the Rabi ploughings. It requires a firm seed bed and therefore the fields are not usually given ^{many} ~~a number of~~ ploughings. Fallow field requires a greater amount of cultivation than those fields that have borne Rabi in it. Heavy Bundelkhand soils are suited for its growth because it requires a firm seed bed and not an open one like Bajra. Fodder is ready in the beginning of September. It is fed to the cattle in the stall or in the field. One mound of dry fodder is equal to 3 mounds of green fodder.

When sown for grains the crop is ready in the middle of November and the heads are cut by a sickle and stack remains in the field till the cultivator is free to harvest it and stock for

future use. Removal of husks is done by cattle. When sowing is done for grains the seed is drilled 20 inches apart.

The Juar fodder is harmful to the cattle if given in semi-parched condition. It is believed by the cultivators to be due to a poison caused by an insect known as 'bhonra' which loses its effects as soon as the rains start again but scientifically it is believed to be due to glucoside formation which breaks up, to produce hydro-cyanic acid.

Bunt and Smut are due to germs which contaminate seed. Mollison (1) believes that fungoid diseases can be controlled more effectively by treating the seed before sowing with $\frac{1}{2}$ per cent solution of copper-sulphate and then ^{giving it a} hot water treatment between 135°F. and 150°F. Poor cultivators ignorant of modern practices take recourse to stale urine as a preventive for fungoid diseases. Mollison further suggests that the stale urine should be poured over the grains and later quick lime in powdered form should be added to the grains to dry it up.

Average out-turn is 8 mounds of grains and 45 mounds of dry fodder, and when grown for fodder an acre yields three hundred mounds of green fodder.

(1) J. Mollison: A text book on Indian Agriculture, vol. III, "Field and Garden Crops of the Bombay Presidency."

BAJRA (PENICILLARIA SPICATA)

Bajra is a grain as well as a fodder crop, though it does not make such an excellent fodder as Juar, still in absence of Juar it is relished by the cattle. The grains have a heating effect and that is why poor people eat this in winter to keep themselves warm (1). It is mainly grown in the western districts and rarely in the eastern. It is usually grown in ~~the~~ tracts ^{with very poor soil.} ~~in the western districts and rarely in the eastern.~~ ~~It is usually grown in the western districts and rarely in the eastern.~~ It can be grown in any type of light soil even on rock wash. Almost every cultivator in the west grows a little Bajra for the use of his family during the winter months, to cope with the severe cold of the western districts.

A glance at the distribution map shows that the main area of Bajra production is in the western districts Agra taking the lead of 22.4 per cent of the total cropped land, Etawah 19 per cent, Budaun 17.5 per cent, Etah 15.3 per cent Aligarh 13.2 per cent and Mainpuri 12.3 per cent. As is well known this crop is very fastidious about its climatic requirements, the dry years usually give a good crop of

(1) Duthy & Fuller: Field and Garden Crop of the U.P.

Bajra. It can not stand a continuous rain and demands a long interval of sunshine between the two falls. It always prefers lighter falls and does not do well in heavier downpours. "Bajra does best when the climate is moderately dry and when the monsoon rains come in light downpours and there is plenty of sunshine between the two showers. Heavy rains are disastrous to germinating seeds or young seedlings and later when the crop has made some progress it is checked in growth and turns yellow during heavy continuous rains. If heavy rains come when the inflorescence is in flower the pollen is washed away and many of the female flowers are not fertilized and therefore the heads of the grains are partially empty. In the Deccan the sowing of Bajra is purposely delayed until the middle of July in order to avoid as far as possible the risks referred to above" (1). Regarding its soil requirements, it can be said that it grows well on poor type of soils of light nature. The typically suited lands for Bajra production are the sandy loams and the outwashes having rocky core. It can also grow on the ravines of Jumna, if brought under cultivation. It is never a crop of importance but plays a very important part in the economic development of

(1) J. Mollison: The Text Book on Indian Agriculture, Vol. III, "Field and Garden Crop of the Bombay Presidency", p. 19.

holdings in the form of utilizing all the poorer and unproductive soils. The main Kharif crop in the western districts where paddy does not grow, e.g. Agra and Aligarh, is ~~Bara~~ ^{either jwar or Bajra.}
~~But the poor type of soils that will not grow any crop~~
~~with the exception of Bajra and jwar.~~ ~~In the western districts~~
~~of Agra, Aligarh and Meerut.~~ The soils are of more open^a nature (light loams to sands) resulting in / concentration of Bajra in these districts.

This is a tract of poor rainfall and the dryness^{which} is preferred for Bajra growing ^{helps towards} and hence the concentration in these districts.

Out of all the western districts Muzaffarnagar and Meerut grow below 5 per cent of Bajra to the total cropped land. These two districts are so highly canalized that they can not afford to grow a poor and dry crop like Bajra.

Etawah district has the next largest concentration in the U. P. It is because the district is full of ravines on which only poor crops like Bajra can grow.

Coming to the methods of cultivation regarding this crop it can safely be said that this crop requires the least attention on the part of the cultivator. The only point is with regard to^{the} selection of suitable land for Bajra cultivation. Once the land is chosen and the seed is sown, the cultivator leaves it to grow all by itself without any further care on his part.

Usually there are two varieties of seeds (a) Bajra of greenish colour (b) Bajra of reddish colour. It is sown a little later than Juar and harvested a little earlier. It is practically never manured and very rarely irrigated. Six pounds of seeds is broadcast per acre and then the field is ploughed. One weeding is given by driving a plough in lines through the field when the plants are about a foot high. This has a good effect as in the case of Juar. About 5 to 7 maunds of grain and 30 maunds of dry fodder is the usual yield.

When the grains have formed, watching is very essential as otherwise the birds and squirrels may completely destroy the crop. The grain ripens in the beginning of November and the heads are cut, after all Rabi sowings have been done. The heads are stocked in a place and trodden by cattle to remove the husk from the grain.

A rain in the beginning of October inhibits the grain formation totally and affects ^{this} ~~the~~ crop more than Juar. Rusts eg. mildew (Puccinia Sp.) also damage the crop but these diseases are all due to the poor land on which it grows. On a better soil and with better care fungal diseases are not so common.

SUGARCANE (SACCHARUM OFFICINARUM)

Sugarcane, though not very important from the point of view of acreage ^{has a potent bearing} ~~still is/very important~~ in relation to world trade. India is the greatest consumer as well as the greatest producer of ^{cane-}sugar. Nearly half of the whole production of India is from the U. P. It has about 2.5 to 3 per cent under this crop. Many new factories have sprung up at different sugar producing centres and at present there are no less than 40 sugar mills working in the U. P. for eight months in the year.

Two areas of production can visibly be noticed. The western plains including the Tarai districts of Bijnor, Pilibhit, Kheri and the canal irrigated tracts of Muzaffernagar, Meerut, Bulandshahr, Moradabad, Bareilly and Shahjahanpore. The second tract of production comprises the Benares division (excluding the trans-ganges tract) and the Gorakhpore division. The concentration in the west is chiefly due to the heavy loams ideally suited for the growth of sugarcane. Heavy rainfall in the Tarai and the facilities for irrigation in the canal tract favour the growth of this crop. From the considerations of climatic requirements, the concentration of sugarcane in the western districts is an anomaly. Geographical control of sugarcane crop by irrigation is the chief factor which has helped the growth of

this crop in western part of U. P. Muzafternagar produces 15.2 per cent of sugarcane to the total cropped land, Bijnor and Pilibhit both produce 13.4 per cent and Meerut 12.2 per cent. Not much of the Tarai canes are irrigated, the heavier rainfall with good amount of winter rainfall is sufficient for the standing crop, it is only in the hot summer months that irrigation becomes a necessity. The crop is generally sown with an irrigation in the month of February, after cotton has been picked from the field. Four or five irrigations are usually needed before the commencement of the rainy season. In the months of October and November when the crop is still standing in the fields it requires one or two irrigations if the monsoons have not been satisfactory. More than two irrigations may be needed if proper inter-cultural operations have not been done to conserve the soil moisture.

In the eastern tract comprising Gorakhpore and Benares divisions a heavy concentration is noticed and ^{it} is not at all difficult to understand such a distribution. Sugarcane follows rice and the good producers of paddy are also good producers of sugarcane. The Bhat (1) soils in Gorakhpore and Basti districts are very well suited to the cultivation of sugarcane. These lands are known as the sugarcane lands

(1) District Gazetteer - Gorakhpore.

of north-eastern U. P. The whole of the eastern tract is a sugarcane producing land and the reason is that the same factors govern the crop production with the only difference that sugar-cane needs more water than paddy. Sugarcane needs more water because it stands in the field for 10 or 11 months whereas paddy remains there for 4 or 5 months. Two successive crops of paddy can be taken from a field whereas only one sugarcane crop can be taken from the same field. The concentration of this crop is purely economic. It is a crop that needs very great labour and care; hence the limit of cultivation of this crop. The greater the amount of manure and water the cultivator commands at his disposal the better is the yield of sugarcane. It also gives a better return to the cultivator than probably all other crops. Soil, water and manure together with the supply of labour are the limiting factors for the sugarcane production. The labour is imported from the adjoining districts to the sugar area. It can be ascertained from statistics that the cultivation of this crop is increasing with leaps and bounds.

Well manured loams and light clays are ideally suited for sugarcane cultivation. Old river beds such as the old bed of the Ganges in the Etah district are utilized for sugarcane (1). The whole of the available manure is applied to the cane fields in the western districts. The crop on

(1) Duthy & Fuller: Field and Garden Crops of the U. P.

the whole is well manured in the Province from east to west and north to south. Banerji suggests a dressing of 200 maunds of farmyard manure per acre or 29 maunds of caster cakes or 40 maunds of 'Mahua' cakes for thin canes and for the thicker varieties, that is chewing canes, he suggests double the above manure (1).

Usually there are two varieties of canes (a) Paunda (chewing canes) (b) Ukh or Ukhri (canes for sugar extraction). Paundas are grown near the big markets for chewing purposes, the variety is M.16. It is more or less included in the garden crops. Given the marketing facilities it fetches a very good price but it can not rise in acreage as sucrose ^{it is} percentage is not very high; hence/not of particular interest for the sugar manufacturers. The other type has many improved varieties e.g. A.42, A.47, Co.214, Co.313, S.48 and S.39. The last two varieties are suitable for both purposes, chewing and sugar manufacturing. A.42 and A.47 do well when sown two feet apart on a flat seed bed. It can stand drought and is not harmed where irrigation facilities do not exist. Therefore it is suitable for the east where canal irrigation does not exist. Co.214 is an early maturing variety and does well only under irrigation, therefore suits the western canal tract. It also commands a good

(1) Benerji, S.C.: Cane and Sugar Cultivation, p. 22.

price because of early maturing capacity and leaves ample time for 'Kharif' preparations. Co.213 is a hard skinned variety which is suitable for places infested by rats and jackals (1).

Regarding cultivation it varies to a great extent from place to place. In Rohilkhand as many as 35 ploughings are not rare; though the average of the Province is 12 to 15 in a field which has been lying fallow. Ploughing starts immediately after the 'Rabi' harvest, usually after an irrigation, but in Rohilkhand and Meerut divisions ploughing can be started even without any irrigation provided the winter rains have been sufficient. Hot weather cultivation is given to the fallow land. Green manuring is practised and further ploughings are also given to maintain the required moisture and tone in the soil.

Two types of cultivation are generally in vogue (a) sowing in lines (b) sowing in trenches.

Trenches are made at the end of October after finishing the 'Rabi' sowing, ~~Trenches are made~~ from $1\frac{1}{2}$ feet to 2 feet wide and 6 inches deep and the distance from the centre of one trench to ~~the centre~~ ^{that} of another is kept at 3 to 4 feet. They ~~are~~ ^{are} dug another 9 inches and filled with manure. Thorough cultivation below the trenches gives very

(1) Mayadas, C.: Studies in Agricultural Improvements in U.P.

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Sugarcane farm with canal irrigation.

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 feet. They usually dig another 2 inches and filled with
 manure. Thorough cultivation below the trenches gives

good results. Oil cakes are usually applied in two doses one while preparing the trenches and the other in May while earthing up the plants. Clarke and Naib Hussain (1) are of opinion that 150 to 180 pounds of nitrogen gives very good results and also that if cane is liberally manured the next wheat crop is very successful. They have obtained a yield of 30 maunds of P.12. wheat in Shahjahanpore Farm from a liberally manured cane field.

Cane is propagated by sets. The selected canes for seed are cut into pieces having 3 nodes or two internodes. The ends of the cuttings are dipped in coal-tar to keep off the attacks of white ants and then cuttings are sown in the trenches at a distance of 6 to 9 inches. An admirable effort to reduce this distance has been made at Gorakhpore and Cawnpore experimental farms, where the writer during his visit found that the distance allowed between two cuttings was only about an inch. The Professor of Agriculture of the Government College Cawnpore believes that such a reduction is quite practicable. The distance of 1 inch is simply allowed to stop a through-boring in case of a white ant attack to the crop. More than this is a useless waste of precious land. After sowing the sets and before germination they are

(1) G. Clarke & Naib Hussain: Notes on Improved Method of Cane Cultivation.

frequently hoed to conserve the soil moisture. The sowing takes place sometimes between February and April and an irrigation after 3 to 4 weeks of sowing is necessary. Sometimes there is rain at the end of March or by the beginning of April which does considerable damage to Rabi crops but saves the irrigation needed in the case of sugarcane. By the middle of May the canes are about 18 inches high when the trenches are gradually filled in and the second dose of oil cake meal is supplied. By the end of June the canes should be considerably earthed up to avoid logging during the rains. The lands should be kept free of weeds during the monsoons. It may need one or more irrigation during October or November if the soil moisture has not been properly conserved or if the rains have withdrawn a little early.

In case of flat sowing as many ploughings as possible are given with improved and native ploughs to maintain a deep tilth after which the land is levelled. Straight lines 3 feet apart are made in the fields and the seed bed is prepared by 'Kassi' (1) in which the cuttings are sown. The crop is frequently hoed. All other practices are the same as in the case of trenching; earthing here again is very important, though not to such an extent as in the case of trenching. Quality and quantity are badly affected in case of a crop in

(1) Kassi is the name given to a wooden implement by which 6 to 9 inches deep seed bed is prepared.

which no earthing has been done, and which is followed by the inevitable risk of crop logging during the rains.

The average yield is about 600 maunds of cane to the acre though 1,000 maunds is not beyond the ken of a cultivator.

Modern methods of sugar manufacture may be seen at Clarke Sugar Factory, Hardoi, and Experimental Farm, Shahjahanpore. There are usually two methods of sugar manufacture (a) the open pan system (Indigenous to India) (b) the vacuum pan system. The Department of Agriculture has accomplished a lot of improvements in cane crushing and juice boiling. The manufacture of spirits from molasses and the future possibilities have been studied and also the utility of molasses as nitrogenous manure returning the soil fertility of the exhausted lands is being tried ~~etc.~~.

McGlashen furnace is suited to the requirements of this Province as the boiling keeps pace with crushing and juice is boiled more quickly and consumes less fuel. Crushing is done in ~~small~~ ^{small} two or three/roller mills and is worked by bullocks in the indigenous system of sugar manufacture. Extraction is poor and the strain is heavy on the animals (2).

(2) Appendix to Report - Royal Agricultural Commission, p.401

Mosaic is a virus disease which is gradually ravaging the sugarcane. It is peculiar in its spreading ways. A sort of patching or mottling is observed on the green leaves of the sugarcane. It can be more easily recognised in a diffused light than in the direct sunlight. The effect is shortening of the internodes and consequent dwarfing of the plants resulting in thinner and lighter canes. Better cultivation seems to have had no effect on the spread of the disease. Mauritius and Shahjahanpur and all the Coimbatore varieties of Paunda are more susceptible to this disease (1).

The control of the disease as suggested by Dey (2) is as follows:-

- 1.. Cultivation of the thick varieties should be discontinued.
2. Ratooning should also be stopped.
3. Selections of sets while sowing should be practised with great care (this had a material effect in controlling mosaic at Shahjahapore farm).
4. Rogueing should be done in earlier part of the year as then it is easier to recognise. The operator must have a trained eye to recognise the disease and while removing the

(1) W. Mc.Rae: Agricul. General of India, Vol. XXI and XXIII, 1928.

(2) W. K. Dey: A Note on the Control of Sugarcane Mosaic in the Eastern District.

debris the operator must be careful to avoid contact with the healthy plants. The operator should also wash his hands and implements after each operation with an antiseptic solution e.g. formalin or lysol.

The next disease to which this crop is subject is the dead-heart borers for which a new method of destruction is suggested by the Mysore Agricultural Department.

Rotations - The most common rotation practised in the Meerut and Agra divisions (cotton tract of U. P.) is cotton in the first year, sugarcane in the second year, a fallow of Kharif of the third year and wheat in the Rabi of the third year. And another important four years' rotation practised in Rohilkhand is sugarcane in the first year, Kharif fallow and wheat in the Rabi of the second year, Juar or Bajra in the Kharif and gram in the Rabi of the third year and green manuring with sunhemp in the Kharif of the fourth year, the Rabi of the fourth year being utilized in the preparations of the seed bed for the sugarcane.

COTTON (GOSSYPIUM HERBACEUM)

Cotton is not a very important crop from the acreage point of view in the U.P. but still the importance of this crop lies in the fact that in Northern India only the U.P. and the Punjab produce any appreciable amount of cotton. It is mainly a crop of the South grown in the Deccan Trap and Berar on the black cotton soil. Leake and Parr have pointed out that "The cotton growing season in the U.P. is characterised by its relative shortness and this aggravated by the nature of the rainfall during the middle period during which the rain is so heavy that the soil is constantly more or less waterlogged and a definite check to the growth of plant occurs" (1). Cotton mainly follows the distribution of wheat and the only wheat tract that does not grow cotton is Bundelkhand. Some thirty years ago Bundelkhand was an important cotton growing centre, but to-day cotton has been replaced by wheat. Various reasons have been put forward for the decline in the cotton area of the Bundelkhand division but that put forward by Burt and Hyder (2) seems very probably the reason, as cited elsewhere. Their opinion is that improvement in communication and consequent rise in the price of food crops

(1) A. J. I. Vol. VI, pt. 1, 1919.

(2) "Bundelkhand Cottons" - B. C. Burt and Nizamuddin Hyder.

like wheat and gram has led to the reduction of non-food crops like cotton. This, added to the variability of monsoons in the U. P. and especially in the Bundelkhand, gave rise to such a change of cropping.

The main concentration of cotton is in the western - Doab districts of U. P., Aligarh taking the lead of about 11.8 per cent, Muttra having 11 per cent and Bulandhshar about 10.7 per cent of the total cropped area. The main cotton tract in the U. P. is the whole of the Meerut division (excluding the district of Dehra-Dun), the whole of the Agra division and the districts of Bijnor and Etawah. The distribution, as has already been pointed out, follows the wheat crop. The alluvial soils of the U. P. vary a great deal from east to west, low lying clay abounds in the east, and the west mainly comprises soils of lighter nature. Light loam is ideal for cotton cultivation. The greater the openness of the soil the greater is the production and hence the concentration. The next important factor that reasons out the causes of chief production in the west is the rainfall which is the main limiting factor for the growth of this crop. The lighter the rainfall the better the growth. During ^a ~~the~~ tour of the author in the Province he ~~has~~ heard experienced agriculturists say round about Cawnpore that ^{the} lower the rainfall the better the crop of either irrigated or rain sown crop. The fact is that the soil becomes waterlogged and does not allow a perfect downward

development of the roots which is so essential for a shrubby crop like this. Besides this crop can not stand waterlogging as that hampers ~~the~~ aeration and ~~hence~~ the growth. This saying is all the same very true for the whole of the western districts where the chief concentration of the crop is found.

Last, though not least, in importance is the problem of irrigation which this crop has to face. Irrigated cotton always gives a better yield than the rain sown one. The western districts of the U. P., as has already been said, have better facilities for irrigation due to canals and cheap electricity available for power pumping. To sum up, it can be said that the concentration of cotton in the western districts is due to light rainfall, facilities for irrigation and lighter types of soil, all of which play a very important part in the production of this crop.

Regarding the cultivation, it is interesting to note that very few ploughings are given to this crop before sowing. It is usually ploughed for the first time when the fields are flooded just before sowing. It is suggested that an immediate flooding after the wheat harvest is of advantage and a second flooding and ploughing should be done just before sowing in the month of May (1). The object^{ion}/to this method

(1) A. J. I. Vol. VI, pt. 1, 1919, .

is that it involves two inundations instead of one and thereby increases the cost of cultivation. The most important point supporting the above suggestion can be understood from the following fact. The government canals are all very busy in the summer months supplying water to the fields for the irrigated crops. But the cotton crop that had had its first inundation just after the wheat harvest would not require so much water for the second flooding. The soil does not bake hard and does not necessitate the breaking of the crusts which involves extra labour and cost. The pressure on the canals is released to a great extent at the most opportune moment.

About 2 to 10 pounds of seeds are broadcast. Seed is rubbed before sowing with cowdung in order to remove the fuzz clinging together in masses. It is also drilled 22 to 26 inches apart and the crop is generally inter-cultured when seedlings are four inches high. Flat sowing is preferred to ridges as the Egyptian system of ridge sowing failed in India (1). Sowing in lines 3ft. by 2 ft. is preferred because it allows of proper inter-culture operations. It has been found by ^{the} Department of Agriculture that the breded variety of Cawnpore-American which is a pure line selection from the original American variety does well in

(1) Pusa Bulletin, No. 88.

this Province. This improved variety does not make any difference in the cropping when compared with the native variety and is a useful cotton of longer staples. The cotton from this seed is greatly in demand in the market chiefly at Cawnpore for the cotton mills. The ginning percentage is also high. Aligarh has two important varieties of its own which are ideal for the western districts, A.19 and J-1. There are two more important varieties K.22 and Cawnpore-American (1).

Cultivation in the case of heavier soils increases whereas it decreases for the lighter soils. One hot weather cultivation after a flooding just after the wheat harvest with a soil turning plough remarkably improves soil texture and ~~xxxxx~~ results in better flowering of the crop.

(2)
Mollison/suggests that the crop should be sown as early after the monsoons as possible, but as a rule two or more sowings are required if the rainfall is very heavy. The character of the season determines to some extent the rotation. Cotton derives more benefit from the residual manures than from a manure directly applied. Manure should be used in a thoroughly decayed condition and preferably should be applied before the rains set in.

(1) C. Mayadas: Studies in Agricultural Improvement in U. P.

(2) J. Mollison: A text book on Indian Agriculture, Vol. III., "Field and Garden Crops of the Bombay Presidency".

It prefers loam where grown alone. It can also grow on poor soils e.g. ravines where it is mixed with pulses and especially Arhar (*Cajanus Indicus*). Picking starts from the month of October to the end of January. Care should be taken to pick as much cotton as possible at the very first picking, because in the earlier months the prices are favourable and later go down. Experience has taught that the earlier the cotton is sown the better is the yield. For early sowing the middle of May is usually the best time. Generally the canal irrigated areas are the first to sow cotton, though a lot of irrigated cotton is sown with well irrigation. Sometimes, due to variability of Indian rains, the early sown crop does not grow well, as there may be a continuous downpour for four or five days or a fall of five inches in a single day. This sort of variation and ^{the} sudden falls damage the crop and inhibit the downward development of roots and also disturb the soil aeration. The idea of early sowing is that the plants may become 12 to 15 inches high before the rains start. At that stage the plants are capable of adjusting themselves according to the environment.

Out-turn varies from 8 to 12 maunds of Kapas (Lint mixed with seeds) per acre. The percentage of lint to Kapas is about 34 varying with the types of seeds. The following results were obtained regarding Cawnpore - American seeds (1).

(1) Pusa Bulletin No. 88.

1. Sown early with irrigation Cawnpore-American is in no way inferior to Desi and given marketing facilities fetches a much better price than the latter.

2. Irrigation arrangements are necessary as the possible sowing time is short and well defined and therefore a considerable area of Cawnpore-American can profitably be grown in canal districts of the U. P.

3. Pure races have been isolated and are found to be superior to the field crop in yield, ginning percentage and uniformity of staples.

Several races with staple of $1\frac{1}{8}$ inches have been obtained. If a cotton of longer staple is required it will probably have to be selected by hybridization.

Cotton improvement has been effected in two ways:-

(a) Hybridization (b) Selection.

The former aims at double character e.g. high yield in lint and long staple. It has been established that cottons capable of spinning higher counts have a low ginning percentage and vice versa, but recent hybridization has given results with better staple (capable of spinning 105 to 125 counts) than the native varieties which have a high ginning percentage (38 to 40). J.1. variety has a better staple than A.19 and is spreading in the districts south of Jumna.

Diseases:- Pink and spotted boll worms are the main insects which cause disease to ~~the~~ the cotton crop and the

former is more destructive than the latter. The former sometimes reduces the value of the crop from 25 to 50 per cent. The only remedy lies in heating the seeds to 140°F. before sowing. Protecting the growing plants by means of wire cages has produced startling effects in coping with these pests (1).

such crops cannot be successfully grown. The hills are sown as an insurance against deficient water supply. The quality of early maturity also favours the production of a large yield.

Manihot (Eleusine Coracana) - This millet is extensively grown in the hills, in Gadh, and in the eastern districts. It prefers a light soil and a light rainfall and suffers from excess. The reason for its concentration in the hill districts is obvious. A good drainage and the light nature of the soil help the growth. The concentration in Gadh and in the eastern districts is rather difficult to understand. Though these places abound in heavy soils, there are still plenty of soils of a light nature available. The heavy soils are utilized for the cultivation of rice and the lighter soils are left for unimportant crops like Manihot. Further this crop is a safe insurance against poor rainfall in the rice districts.

It is usually sown early, with very little cultivation.

SMALL MILLETS.

Mandua, Kodon and Sawan all are collectively known as small millets. They are grown on 5 per cent of the total cultivated land. Though they do not materially add to the purse of the cultivator, they furnish enough reserve of food material for his home consumption. In localities where cash crops cannot be successfully grown, the millets are sown as an insurance against deficient water supply. The quality of early maturity also favours the production on a large scale.

Mandua (Eleusine Coracana):- This millet is extensively grown in the hills, in Oudh, and in the eastern districts. It prefers a light soil and a light rainfall and suffers from excess. The reason for its concentration in the hill districts is obvious. A good drainage and the light nature of the soil helps the growth. The concentration in Oudh and in the eastern districts is rather difficult to understand. Though these places abound in heavy soil, there are still plenty of soils of a light nature available. The heavy soils are utilised for the cultivation of rice and the lighter soils are left for unimportant crops like Mandua. Further this crop is a safe insurance against poor rainfall in the rice districts.

It is usually sown early, with very little cultivation.

The crop ripens in August and gives a heavy return of grains. Practically no inter-cultivation is given and it is left in the field unattended.

Kodon (*Paspalum Scrobiculatum*):- This particular millet also does well in dry seasons and suffers not only from excess but from abnormal dryness. It is usually grown in poor lands (1) such as those of Bundelkhand and Mirzapur. It is also grown in Oudh in the poor soils and more generally it is mixed with rice, to cope with the vagaries of weather. A higher percentage of this crop in a particular locality signifies the poverty of the land and the people.

It ripens late, usually in the month of October, and does not leave ample time for the Rabi preparations.

Sawan (*Panicum Frumentaceum*):- This prefers a light soil and does well with a light rainfall and suffers from excess. It is also grown widely by poor people for reserve food, and is commonly grown in Rohilkhand, Bundelkhand and the eastern districts. The crop is important for its early maturing quality as it ripens in August as does Mandua. It is usually sown with the first showers of the monsoons. The method of sowing is the same as that of the broadcast rice.

(1) A. H. Church: Food Grains in India, p. 39.

Sann-Hemp (*Crotolaria Juncea*):- This crop follows the lines of production of sugarcane, as the climatic and soil requirements are approximately the same as that of the last-mentioned crop. With normal weather and correct sowing time, it gives a good return. Improved varieties providing better length and quality of fibre are extensively distributed. It is of great economic importance for the sugarcane crop, as it maintains and improves the soil fertility. It is also very useful as a green manuring crop in the absence of adequate supplies of organic matter. It is an essential item in the trade of the Province as large quantities are exported to Europe from Rohilkhand, Benares, Oudh and Bundelkhand. The fibres are made into strings and are used in the manufacture of gunnybags. It is sown increasingly by itself but is often a border to cotton and juar fields. The leafy tops are cut when the crop is in flower (to get better fibre) and fed to the cattle. This supplies combined nitrogen to the soil and leaves the land free of weeds and in good condition.

Indigo (*Indigofera Tinctoria*):- This was a very important crop about 3 or 4 decades ago but the synthetic German dyes have dealt a death blow to indigo factories. It is mostly grown as a green manuring crop to-day. Excessive rain is detrimental to the quantity of dye. It is usually sown with the rains and when the plants are about 2 months

old they are ploughed in for the purposes of green manuring. It grows well in poor land with rough tillage.

Potato:- Water and manure are the two great essentials for this crop. It is commonly grown in hills (from which it is exported to the plains) and also round the larger towns where ample sewage and night soil are available. The production is spreading in the smaller towns and also in the villages. The best potatoes are grown in Nainital. The usual crop after potato is maize. The digging of the tubes breaks up the soil splendidly and leaves it clean for the next crop. A three crop rotation, - potato, maize, tobacco, is very important in the Farrukhabad district which is to a great extent responsible for the agricultural prosperity of that district.

Tobacco:- Tobacco is a crop of fairly recent origin. It grows well in heavily manured fields and prefers clay, loams or heavy alluvial soils situated near the village site. Irrigation once a fortnight gives good results. Well-irrigation is more beneficial than canal water.⁽¹⁾ Seedlings are raised in nurseries and then transplanted while they are moist, and the soil is thoroughly pulverized before sowing. The crop can be grown twice a year - the first planted during October ~~and~~ ripening in February; with the second, the seedlings are planted in February and ripen in the month of May. Two crops cannot be raised from the same field. The

(1) It prefers well water as against canal ^{water} because the ~~latter~~ former has less dissolved salts than the latter, & the crop being very fastidious to salt requirements.

greatest danger to the early variety is frost while to the later variety it is hail-storms in the month of April.

Oil Seeds (Linseed, Sesame or Til Mustard, Ground Nut and Castor):-

Linseed (*Linum Usitatissimum*):- Linseed is grown for seed as well as for fibre. In India it is mostly grown for seeds while in Europe it is mainly grown for fibre, hence the Indian plants have a number of short branches and the European plants a single long stems.

The plant prefers heavy clay soils and is therefore grown in the black soils of Bundelkhand and the rice districts of the east. Rarely any irrigation is needed for the crop. 3 or 4 ploughings are given after the seeds have been scattered in the damp soil. Oil is extracted by the indigenous method of two bullocks working on a simple wooden mill. The oil is used for the manufacture of hair oils and also for medicinal purposes. Oil cakes which are left as by-products furnish a nourishing cattle food.

Til (*Sesamum Indicum*):- It is usually sown with Juar, Bajra and Cotton. It is either sown broadcast or sown in lines with the other crops. It is ready for harvesting by the end of October or the beginning of November. The concentration is mainly to be found in the sub-montane districts and Bundelkhand. Two varieties of seed are known (a) black-seed variety (b) white-seed variety. The oil

content in both varieties is nearly the same and is extracted as in the case of linseed. Cakes furnish an excellent food for the cattle.

Mustard (*Brassica Compestris*):-- It is sown as a border to the Rabi crops. It is either broadcast or sown in line with other crops and very rarely sown alone. There are many varieties of seeds. The chief danger to this crop is damp cloudy weather while it is growing as an aphid known as Mahun spreads and sucks the sap away. The oil is mostly used for cooking and burning. Extraction of oil is done in the same way as in other oil seeds.

Ground Nut (*Arachis Hypogea*):- It requires a light well-drained loam and is very sensitive to water-logging. Sowing in May with irrigation has beneficial effects, but another irrigation is needed if the rains have stopped earlier. The nuts are ready to be dug in November and December. The crop has a good future as it fetches a good price, and leaves the field in good condition after harvest.

Castor (*Ricinus Communis*):- It is grown mainly as a hedge to sugarcane, cotton and other Kharif crops. It ripens in March, and the main use of the oil is in lubrication and burning.

Large quantities of oil seeds are exported to Europe every year. They are very soil-exhausting crops and to export them is to export the soil's fertility.

Opium (*Papaver Somniferum*):- The crop is a government monopoly and licence is given to cultivators. It requires a great deal of labour for cultivation. Richly manured heavy loams or light clays are preferred. The soil is thoroughly pulverised as it requires a well-prepared seed-bed. A top dressing of salt-petre or powdered dung is very useful and often the crop is manured with ashes. It needs several irrigations. Well water, having a greater nitrate content, is preferred to any other kind of irrigation water. Clean cultivation is very necessary. The growth of the crop is slow until February after which it matures with rapid strides.

When the capsules are swollen a scratch with a knife is made in the evening and the gummy juice is collected in the morning. This substance is known as opium. The process of lancing has to be repeated several times before all the opium is collected. It is a very laborious process and needs a certain amount of care on the part of the operator which is acquired only by practice.

After the extraction of opium the capsules are used as poultices. Oil is extracted from the seed which is used for medicinal purposes and the cakes furnish cattle food.

The successful cultivation of this crop depends mainly on the weather. Damp, east winds late in the season cause damage. The U.P., Malwa and Bihar were formerly the chief

opium producing centres, but to-day, due to a change in the government policy, cultivation has been reduced to about 10 per cent.

Uttar Pradesh is the leading province in India regarding the number of livestock. According to last cattle census taken in 1935, the Province had 35,485,552 bovine cattle (cows and buffaloes) 12,301,747 ovine cattle (sheep and goats) and 914,711 of other description.

The cattle are fairly well distributed throughout the whole Province. The density is highest in Fyzabad and Gorakhpur Divisions where the highest figure for a district is 977 cattle per square mile. The distribution of cattle in this Province corresponds very closely with the distribution of human population. If the density of cattle per 1,000 human beings be taken, Mainpuri, Jhansi and Banda become the leading districts. The reason is that human population is small and ample grazing facilities are available and hence a greater density of cattle per thousand human beings in these districts.

Cattle are very important from an agricultural point of view as they form the chief draught animals of the Province and the only source of power. "Cattle are the life of the cultivator" (1).

(1) C. K. Jha: The Supply of Agricultural Cattle in India, A.S.I. Vol. VII, pt. 2, 1932, pp. 141-142.

LIVESTOCK IN THE UNITED PROVINCES.

The United Provinces is the leading province in India regarding the number of livestock. According to last cattle census taken in 1935, the Province had 32,469,552 bovine cattle (oxen and buffalos) 10,001,747 ovine cattle (sheep and goats) and 817,711 of other description.

The cattle are fairly well distributed throughout the whole Province. The density is highest in Fyzabad and Gorakhpur Divisions where the highest figure for a district is 477 cattle per square mile. The distribution of cattle in this Province corresponds very nicely with the distribution of human population. If the density of cattle per 1,000 human beings be taken, Nainital, Jhansi and Banda become the leading districts. The reason is that human population is small and ample grazing facilities are available and hence a greater density of cattle per thousand human beings in these districts.

Cattle are very important from an agricultural point of view as they form the chief draught animals of the Province and the only motive power. "Outside his own family there is nothing that fills so large a share of the cultivator's thought as his land and cattle" (1).

(1) C. E. Low: The Supply of Agricultural Cattle in India, A.J.I. Vol. VII, pt. 4, 1912, pp. 331 - 342.

Breeds and types of cattle of the United Provinces.

Cattle improvement in this Province is a question of recent origin. The first cattle census was taken as late as 1908 - 9 which signifies how late the people became conscious of the importance of cattle improvement. Pedigree herds were out of the question. Selection had to be effected from the existing stock, the result was that by slow and conscious movement towards breeding better stock quite a number of distinct types can be recognized today. Breeding requires a good deal of experience before one can become a successful breeder. Besides, it requires an enterprise the results of which are in the womb of the future and are not easy to foretell.

For the purposes of considering the existing breeds in the U. P. the Province should be divided into 5 tracts.

1. Montane tract - includes all the hill portions embraced within this Province, this tract is not precarious in its water requirements and has a rainfall of over 60 inches.

2. Sub-montane tract - a tract of about 30 to 40 miles broad, bounded on the north by the foothills of the Himalayas and on the north-east by the Nepal Tarai. It extends from Saharanpur to Gorakhpur and has a rainfall between 35 and 50 inches, rainfall increases from west to east and from south to north. The main crops are sugarcane and rice.

Contrary to expectation fodder is not grown in that excess as it should because of the abundance of pasture lands in this region.

3. Dry Western tract - this is the tract roughly corresponding to the wheat tract already discussed on the chapter relating to the geographical and natural divisions of the Province. This tract includes all the Doab districts west of Cawnpore. Rainfall varies from 23 to 32 inches per annum. It includes the non-tarai part of Saharanpur district together with the districts of Muzaffarnagar, Meerut and Bulandshahr of the Meerut Division, the whole of Agra Division and the districts of Farrukhabad, Etawah and Cawnpore of the Allahabad Division. This is the part of the Province which is ideal for the concentration of the important breeds because the climatic conditions are similar to that of the Punjab. The Punjab cattle that are brought here have not to undergo the process of acclimatization as they get the same conditions of life as their native province, regarding climate and other physical environments. Fodder is ~~grown~~ ^{in large quantities} grown/as there are not enough pasture lands. The only grazing land/^{that} is available is at the Ganges and the Jumna Khadir.

4. Humid Eastern tract - it includes rest of the U. P. excluding the Bundelkhand Division. Rainfall varies between 32 and 45 inches. Being a humid tract it mainly

grows rice. The cattle of this tract are not so strong as those of the dry western tract and the general trend is that cattle deteriorate from west to east.

5. Bundelkhand tract - it includes whole of the Bundelkhand Division. Rainfall varies from 31 to 37 inches. The cattle are of light draft type. Fodder is sparingly grown as the tract affords good pasture lands.

Coming to the breeds, the Province has about 7 distinct breeds with the greater majority of mixed types. The breeds are as follows:-

1. Haryana - this is a dual purpose draft cattle. They have been introduced in the Province from the Punjab and hence the dry western tract suits the requirements for the growth and concentration of this breed in the aforesaid tract. Bullocks of this breed are generally used by the wealthy cultivators. This breed is mainly centred round the dry western tract though a few are also found in the humid eastern tract.

2. Mehwati - this is a dual purpose medium draft cattle concentrated round about the districts bordering Rajputana country where Haryana and other smaller Desi/varieties of cattle are also found. They are mainly used in the dry western tract and also largely used in the humid eastern tract. The bullocks are popular with the cultivators of the west. Cows are popular with the cultivators of the west. Cows have

have good milking capacity and with proper breeding will turn out cattle which will not only be suitable to this locality but probably for the Province as a whole. They are also distributed in the native states of Bharatpur and Alwar. Bulls of this breed will be very suitable for grading up the local desi cattle of the humid region where no suitable breed exists and the cattle of this breed will always be in constant demand in the dry western tract. The price for the cattle of this breed is not so high as that of Haryana and hence is within the means of the average cultivators to purchase the cattle of this breed.

3. Kherigarh - this is a light draft animal, and is generally located throughout the whole sub-montane tract. Kheri and the neighbouring districts are the main breeding grounds. The cattle of this breed ^{are} ~~is~~ generally in demand for the north-eastern districts eg. Gorakhpur, Basti, Gonda and Bahraich and also in the humid eastern tract. This is a light type of cattle and is fairly active in its work.

4. Ponwar - this is also a light draft animal found in the eastern districts of the sub-montane zone along with the Kherigarh breed and also in the humid eastern tract. The breeding ground for this breed is centred round Pilibhit. This is an attractive breed of black and white cattle and is slightly heavier and slightly less active than the Kherigarh. Both breeds are very hardy animals and sufficient fodder

together with grazing lands will enable large herds to be established at different centres in sub-montane zone. Both these breeds are used in the eastern sub-montane districts and the humid eastern tract. The bulls of these two breeds can be used for grading up the local cattle of this tract.

5. Kenwaria - this is a light draft breed of cattle located in the Bundelkhand. The Bundelkhand cultivators have now started showing interest in the cattle problem which is a matter of great importance for them. In consequence the government has established cattle breeding centres in Bundelkhand.

6. Hill cattle - this is a light draft very small type of cattle, ~~and~~ mostly ^{found} in the three hill districts of the Province. They are a mixed and ill-defined type and no improvement in grading up or providing the sires for the cows has been done so far. The only possible selection can be made from the existing types as the bigger and better cattle from the plains will have numberless difficulties to encounter in acclimatizing themselves to the hill conditions; probably they will all die before this actually takes place.

7. Montgomery - this is also known as the Sahiwal breed and is very important from the point of view of milk production but not for work. This is also imported from the Punjab only for dairy purposes. Cows of this breed are distributed in the dry western tract for milk. These cows

have proved very successful regarding acclimatization. They have been able to stand the tarai conditions at the Manjhra farm (Kheri dt.). The wet and trying climate of the place has had no ill effect on them. Results so far obtained are very hopeful.⁽¹⁾ The cows of this breed are centred round the dry western tract because of the location of dairy farming business.

There are two breeds of buffalos in the Province:-

a. Murrah - they are mainly concentrated in the dry western tract and are slightly more active than the desi variety. This is a dual purpose breed. They are good milkers as well as good workers though slower and more sluggish when compared to the bullocks of any of the above mentioned breeds. Regarding the milking capacity, an average Murrah buffalo yields about 20 to 25 lbs. of milk per day.

b. Desi - this is distributed in the rest of the Province and is a bit slower and more sluggish when compared to the other variety. Both the types are very hardy and any condition can suit them though Murrah is a bit fastidious regarding the problem of acclimatization. Grading up of the desi type in the Bundelkhand Division will go a long way in solving the cattle problem of that locality.

Choosing of breeds for suitable localities:-

Moreland and Oliver suggest the following breeds for the

(1) Evidence taken in the U. P. - C. H. Parr: Royal Agric. Commission in India, Vol. VII, pp. 440 - 49.

following (1) localities:-

1. Kherigarh is suited for the whole of Oudh as far as east as Gorakhpur and Ballia. They are excellent workers but poor milkers and are not at all fastidious regarding their food requirements.
2. Ponwar is suited to the Rohilkhand Division. They are small cattle and good workers but not milkers.
3. Haryana is suited to Meerut Division. The cattle are big, strong and hardy and also good milkers.
4. Mehwati is suited for the Agra Division. They are medium sized cattle, good workers and fair milkers.
5. Kenwaria - the breed is ideal for the Bundelkhand Division. The cattle are of medium size, they are good workers as well as fair milkers.
6. Montgomery - this is a strong breed of cattle not indigenous to this Province. They are imported from the Punjab, mainly for dairy purposes. The bullocks are not very good workers, and are rather slow for the plough.
7. To this should be added a last type known as the hill type. This is not a distinct breed but is a mixed and ill defined type of very small cattle suited to the agricultural conditions of the hills.

(1) Oliver & Moreland: Notes on the Improvement of Cattle in U. P., pp. 1 - 3.

Improvement:- If any improvement has to be effected regarding the breed of the cattle discussed above the government should establish breeding stations for grading up the existing types of cattle. By this is not meant that the government should supply all the bulls but that the bulls from the government breeding stations may be used in such a way by the cultivators that the qualities inherited from the pedigree may not be lost.

Controlled areas to act as breeding stations were started at Muttra and Etawah districts with the help of District Boards and Civil Veterinary Depots. The bulls were distributed to the approved breeders and zamindars for popularizing breeding. The following defects were experienced regarding this system (a) the financial resources of the District Board being very limited only a few bulls could be maintained. (b) the approved breeders and zamindars were apathetic towards the bulls and the appropriation of money supplied by the District Board caused the deterioration of the bulls. This led to inspection by the cattle inspectors which made the item a very expensive one. The conditions of the bulls inspected were found either low or very poor.

Organization of controlled breeding areas have proved the following:-

1. Need of good bulls.
2. Zamindars and cattle owners willing to contribute

towards the initial cost of the bulls.

3. Their willingness to maintain the bulls without any outside help, and lastly

Contrary to the general opinion the zamindars and village breeders were not apathetic towards the bulls and their improvement; ~~but~~ ^{they} instead/showed a keen interest and a genuine desire to make the best use of them. An experiment tried at Muttra controlled breeding area of the possible use of Tagavi loan advanced by the government of a sum of Rs. 40,000/- has been put at the disposal of the cattle breeding department. The above sum will be utilized in providing bulls against the security of the breeders and the zamindars and this sum added with $7\frac{1}{2}\%$ interest will be paid back to the government. The scheme has proved very fruitful with such a small sum and with a very nominal cost to the government in ^{the} form of the pay of the staff engaged in working out this scheme (1).

Another formidable obstacle against cattle improvement is in the form of the dedicated bulls. These bulls should be taken care of by the department and castrated wherever possible.

In western districts/^{only} castrated bulls ~~only~~ are used for draft purposes whereas in the east and the sub-montane tracts

(1) Evidence taken in the U. P. - C. H. Parr: Royal Agricultural Commission in India, Vol. VII, pp. 440 - 449.

uncastrated bulls are also often used for the same purpose ⁱⁿ which is a positive drawback ~~towards~~ cattle improvement.

Pressure on the grazing lands:-

The following description will enable the readers to understand how the pressure on the grazing land has been increased.

1. Grazing areas are over-stocked because the grazing fee is charged per head of cattle. If the number of grazing lands were sufficient such unfortunate cases would not have attracted notice.

2. The pressure on the grazing land has also increased because of the sentimental idea, though humane in its origin, still not very practicable, of keeping the cattle that have crossed the working age. It is not desirable that the general mass of cattle should suffer for the sake of a few old ones.

3. There seems practically no supplementation of heavy yielding fodder crops under irrigation probably because the cultivator does not get the proper return from fodder crops.

(1). With proper transport and marketing facilities the cultivators will learn the potentialities of future development of the cattle as this is the only motive power of the Indian cultivator and any deterioration towards this side will

(1) C. H. Parr: Fodder Famine Relief in the United Province, A. J. I. Vol. XXII, pt. 2, 1927, pp. 98 - 104.

effect the whole agricultural industry.

4. Absence of green fodder in the summer months is not a matter of serious anxiety for the working cattle but undoubtedly effects the milk yield for which the best solution is the silage in kachcha pits. Two periods of fodder shortage are marked in the Province (a) month of March when the Rabi fodder is not ready and the preceding Kharif fodder is nearly exhausted (b) the month of June when the Rabi fodder has nearly depleted and the monsoon grasses have not begun to grow.

5. Deficiency in the mineral constituents in fodder of different localities is also one of the reasons why pressure on the grazing land increases at a particular locality. Probably this is one of the main reasons why the cattle deteriorate from the west to the east. A change from dry to green fodder and vice versa causes a bad tone in the system of Indian cattle and it takes about a month to recuperate their health. Fresh and healthy appearance of the cattle of the dry western tract after a month of the production of green fodder is a sure sign of better feeding value of the western fodder.

Improvements in the grazing areas can be effected by bunding the grazing lands which will avoid ravining and also by controlled grazing to allow reseedling to take place. A particular controlled grazing area should always be kept in

reserve to fight drought and famine conditions. Sufficient fodder could be grown round about the breeding tracts as the transport of bulky commodity like fodder is a difficult problem at times of emergency. The growing of irrigated fodder is also a practical suggestion towards cattle improvement. Dry western tract where the cattle are of a better type should be guarded against fodder famine. Afforestation of ravines of Jumna and other rivers affords good pasture land and reduces ravining to a very great extent. The forest department has shown that the afforestation of the ravines afford "pasture lands of no mean value" (1). This problem should further be studied by the Department of Agriculture in all its aspects and at a future date it should be able to give a definite answer to the problem.

Cattle supply and grazing lands:-

A practical equilibrium is maintained at the present day taking the Province as a whole excluding the Himalayas. Within this area the cultivators can pay the price for the cattle they require leaving of course the famine out of question. They can also feed the cattle they keep. It does not seem necessary to furnish evidences in support of these two statements, though it is possible to point out areas where they are not for a moment true, but their general

(1) Evidence taken in the U. P. - C. H. Parr: Op. Cit.
pp. 440 - 449.

truth will not be disputed by any one who knows the Province as a whole. If it were false, return of cultivated area and revenue collection would have afforded an early and conclusive proof. Moreland is of opinion "That the equilibrium of food to cattle is not an accident or a spontaneous adjustment but is the result of conscious process" (1). Cultivators in the great majority of cases neither buy nor sell fodder for they know that the fodder is the main stay of their cattle which is their prime motive power. An economist would suggest to substitute cash crops as cotton for fodder but the cultivators have to make provision for their cattle. Therefore, only the extra lands could be utilized for cotton but not those that are necessary for fodder growing.

Disturbing force:-

The greatest disturbing force of the existing equilibrium is the tendency towards extended cultivation reducing thereby the area of the grazing lands. This tendency of extended cultivation/ in itself is dependent upon (a) pressure of population (b) rise in the standard of living (c) development of trade (d) improvement of communications, railways and roads. The disturbance caused by extended cultivation is adjusted fairly rapidly by the activities of

(1) Moreland: Cattle Supply of the U. P.

the individual cultivators. When the number of cattle is greater than the grazing land could support, the tendency is rise in the fodder land so that an equilibrium is maintained between the cattle and food. But the tendency to disturb the equilibrium in the supply of cattle is in all probability not so quickly counteracted.

It is unnecessary to discuss here the causes that result in extended cultivation. The main fact is that the country wants larger income and the Province being an agricultural one, the only possible source is through extended cultivation. Undoubtedly many people remain under-fed, ill-fed or partially fed in spite of extended cultivation. But so far as the demand for food rises it is a matter of real gratification provided the factor of density of population is taken into account. If the demand for food increases with an increase in population, it is not very satisfactory but if the demand increases more than the population demands it means that the under-fed population is getting more food than they received previously. This goes to show an increased prosperity. The export of agricultural commodities is again a matter of satisfaction as it is a healthy sign of prosperity, happiness and better feeding. The only disadvantages in export is that the produce of the land is not utilised in the Province and indirectly a part of soil fertility is exported to other places. The export

should also be limited so that a little surplus may always remain in the country to cope with emergencies such as famine and drought. These considerations therefore justify the view that extended cultivation in itself is a thing to be desired. So far as it is known it results in an improved standard of living.

Another very important effect of extended cultivation is the tendency towards rise in the price of cattle which in the author's opinion is one of the best signs for the rise of peasantry of a country. The higher price will stop or at least lessen the import of cattle and the cultivators will undoubtedly take a better care towards the upkeep and feeding of the young stock and they will try to procure a better sire for their cows either severally or on a co-operative basis. The effect will be a great stimulus towards cattle breeding and their improvement. Besides, if this business could be carried out successfully in the Province and once a reputation of the cattle could be established, working cattle and breeding bulls could be exported to other provinces having inferior stock, e.g. Bengal.

Now for feeding the cattle the cultivator will require an extended cultivation of fodder for the cattle. For a certain number of years extended cultivation will work on all right but later on the lands on the margin of cultivation will revert to grazing, until the equilibrium in values is restored.

To explain this, it can be said that it all depends on the relative value whether the land is going to remain under the plough or under grazing. The marginal lands which could be utilised as a grazing land with profit will eventually remain under grazing. Lands for market gardening round about big towns e.g. Lucknow, Agra, Cawnpore, Benares which will always fetch a good profit will invariably remain under the plough and will never revert to grazing. Similarly the lands near the Jumna ravines, the tarai and the hilly sides of Bundelkhand where cultivation is out of the question give a definite assurance to remain as grazing lands.

The interchangibility of lands from grazing to cultivated and vice versa is beautifully illustrated by the recent history of the river side low lands which in turn has gone from grazing to cultivated and the opposite. Parts of Bundelkhand have taken grazing as a more profitable proposition. Cultivated area is practically the measure of the demand of cattle. It could therefore be said that the land under the margin of grazing and cultivation will depend upon the equilibrium between the supply and demand of cattle.

Cattle supply and fodder:-

A glance at the season and crop reports will show that the percentage of irrigated total fodder crops in the U. P. is the greatest in the districts of the dry western tract. This beautifully illustrates the co-relation of the best

breeds of cattle to irrigated fodder. The western tract is mainly wheat and gram producing area whereas in the eastern region rice predominates. Wheat gives very concentrated fodder for the use of cattle and gram supplies ~~with~~ a most delicious fodder, the result is the natural concentration of hardier and bigger types of animals in this tract. In the rice-predominating regions ^{The cattle obtain} ~~the cattle obtain~~ very poor fodder. Rice fodder is neither nourishing nor is liked by cattle and hence is very sparingly given to the cattle. Cattle as a result of this ~~factor~~ deteriorate from west to east. The green fodder produced in the eastern and north-eastern tract is also deficient in mineral matters, the obvious result is poor health and shorter cattle.

The amount of irrigated fodder is very limited in the Province ^{of which} ~~the~~ the major portion ^{of which} is in the dry western tract. This goes to prove that in this tract the people get a better return for the value of irrigated fodder by feeding them to cattle which are unquestionably of the best type. The sign is a very hopeful one regarding the cattle industry of the Province for the near future.

Milk Production and Dairy Industry:-

The buffalos are the chief dairy animals of the Province, though there are cows in the western dry tract which are capable of giving a fair yield of milk of 300 gallons per lactation period but still the buffalos are the

profitable dairy animals. The dry western tract is fairly well supplied with the indigenous types of buffalos and also Murrah buffalos. Cows of good milk yield are also to be found here and hence it can be said that this tract is well supplied with cattle both as regards draught and milk.

The milk capacity of cow decreases in the central humid tract and is further decreased in the sub-montane area. Buffalos of local type are to be found as the Murrah buffalos lose their milk capacity when they come to these tracts. In the sub-montane area the milk capacity of the cows is just sufficient to feed their young ones therefore the milk supply is dependent upon the buffalos. They too produce very little milk. The deterioration in size, strength, and milk capacity in the eastern tract is ascribed to deficiencies in the soil and water, to inferior grass and fodder and to, unsuitable climatic conditions.

Bundelkhand has the greatest number of milch animals because of available grazing land. It has an average of 365 milch animals per 1,000 human population. The districts of Benares and Lucknow are especially deficient in ^{the} number of milch animals, the average being 122 and 130 respectively per 1,000 human population. The reason is that these two districts have a very high proportion of urban population with comparatively small rural areas and grazing lands. Other districts are not so badly off.

No figures of milk yield per cow or she-buffalo is available but a cow in this Province seldom gives more than 5 seers a day while in eastern districts there are cows which yield only about one seer of milk. A fair average should be about 2 seers of milk per cow and about 3 seers for a she-buffalo. Taking the two together it becomes $2\frac{1}{2}$ seers per milch animal. There are about 207 milch animals per 1,000 population or roughly 2 milch animals for every 10 people. One half of these remain dry and the other half are in lactation so that it comes to 1 milch animal for every 10 people, or each man receives about a quarter seer of milk which is not sufficient.

The milk capacity of the Province is greater than the purchasing capacity of the consumer. Ghosees or Gwalas who act as middlemen for the supply of milk are the most unscrupulous type, of people. They freely practice adulteration. They purchase all the available fodder within a radius of 8 to 10 miles of a town and act as the sole agents for the supply of milk. The result is a limited area for the milk market which makes the supply expensive and deficient. The sanitary conditions are also not taken into account and generally the milk supply is under unhygienic conditions. The villages situated at a distance of more than 8 to 10 miles take recourse to production of Ghi, the bye-product is utilised for home consumption. Ghi is adulterated with

vegetable oils and animal fats. Even for the consumers who are prepared to pay a fair price, it is not possible to get absolutely pure ghi unless indented from the villages. It is not possible to bring the consumer and the supplier together and therefore there are greater chances of adulteration. As soon as the Ghi comes from the village producer to the middlemen in the town they take the first opportunity of adulterating the product, keeping it ready for the use of consumers. The only possible remedy lies in the following:-

1. A food adulteration act by the municipality.

2. Licensed middlemen, whose product could be inspected by the officers of health without any previous notice and both these acts should be rigidly followed and anybody breaking the laws should be given exemplary punishment.

3. Collecting centres for milk should be established at the villages under the control of men of position and they should be under the control of the officers of health.

4. Facilities for better roads should be provided.

In case of over production, markets outside India should be investigated to enable the supply of condensed dairy products.

Thus it is possible to increase the amount of milk normally produced in a village and the development of such schemes greatly encourages improved methods of cattle ~~breeding and management~~

breeding and management (1).

The reason why the dairy industry is centred round Aligarh is due to the fact that government had established a dairy farm under the care of a Swedish expert, but later on the farm was sold to him. The farm is thriving now. Other people have ^{also}diverted their attention towards this side and hence the concentration in this district.

(1) C. H. Parr: The Need for the Development of Dairying as a Village Industry and some of the Probable Result, A. J. I. Vol. XXII, pt. 1, 1927, pp. 30 - 33.

COMMUNICATIONS.CHAPTER VII.

The United Provinces is very well supplied with roads and railways. Only Madras and Bombay presidencies lead this Province in road construction and the Province, with these two exceptions, is far above the average of other provinces in India. The Province has about 1 mile of railway for 19 sq. miles and 1 mile of metalled road for every 12 sq. miles. Even so the Province is always demanding new roads and railway lines. Construction is constantly being undertaken and a few miles of railways are being added every year. Since the end of last century the mileage of roads and railways has been practically doubled, but the demand is still as great as ever. At the close of the last century the Province had only 3,000 miles of railways and 5,000 miles of metalled roads and at the end of the last year it was 6,000 and 10,000 miles respectively. Roads in the modern sense of the word and railways are the outcome of British rule in India. The Grand Trunk Road - a very important military road - was built during the reign of Sher Shah Suri; it runs from Calcutta to Peshawar, a distance of about 1,500 miles and passes through the entire length of the Province.

The worst conditions of the Indian roads were found during the period of confusion when the Moghul powers had

A TOWN of recent origin due to sugarcane farming (See station).



long been dispelled and the British were trying to make a solid footing in India. Due to their hard struggle to establish an empire in India the British could not divert the attention towards channels of public utility, the roads fell into disrepair due to marching and retreating of the armies and hence were abandoned. The only highways used by the people were the rivers, wheeled traffic being practically unknown. This slow movement of traffic caused great fluctuations in the prices of agricultural commodities. One part of the Province suffered from the pangs of famine whereas the other part did not know what to do with surplus food. The distressed areas could not be supplied due to the difficulties in transport. The western part of the Province, which was not canalized at that time, was a constant scene of disaster. The Trans-Jumna tract with the greatest variability of weather suffered the most whereas the eastern part of the Province with an adequate and fairly secure rainfall was smiling with waving green fields. The bad condition of the roads and their disuse made them the rendezvous of thieves and robbers. This checked emigration to a great extent; people fought dauntless fights against the adverse conditions and often died in their homes. Such is the sorrowful story caused by the bad condition of the roads. Relief could be given to the people by means of the river route, and this helped but little.

The British, by experience, realised the necessity for good roads and for the first time repaired the old Grand Trunk Road for the use of the public after they were free from their military and political sojourns in 1832. Before the Mutiny there was no metalled road in Oudh except that from Cawnpore to Lucknow. As funds became available slowly and gradually the roads began to be built. When the British took possession of this Province, there were only two important provincial arteries other than The Grand Trunk Road, one from Delhi to Allahabad via Muttra and Agra following the line of the Jumna, and the other from Garhmuktesar in Meerut to Benares and then to Patna the capital of Bihar, via Moradabad, Bareilly and Lucknow.

In the old days when the geographical position of the country was not studied on a large scale and the science of road making was not advanced, the roads mainly followed the rivers which were the chief highways of commerce and trade of the country. The banks of the rivers were studded with large and important towns and collected the trade from the surrounding agricultural area, so that the roads of necessity had to follow the course of the rivers. Difficulties arose only when the rivers left their courses and this was overcome by building minor roads joining the present course to the established towns. With the well-established rule of the new regime and with a fair amount of security new

towns began to spring up as collecting centres for the rural produce. The next important need was therefore to connect these towns for the carriage of the produce to the markets at the sea-board. The result is that we now see many roads linking nearly all the important collecting centres to the "sea-front."

By 1856, branches were completed from Delhi and Khurja (about 25 miles north of Aligarh) to Meerut, Aligarh to Agra. Other important contributions are Meerut to Saharanpur and from the latter to Dehra Dun, Bareilly to Maini-tal, and Kathgodam to Almora, Dehra Dun to Mussoorie, Bareilly to Muttra, Agra to Mainpuri joining the Grand Trunk Road to Bewar. Garhmuktesar, the terminus of one of the main provincial arteries, was extended to Delhi and Meerut. This is all the important advancement in the making of roads in the western districts of the Province by the Central Provincial Government. The district boards in each district have also added as funds have permitted.

In the other half of the Province more important additions were made as that happened to be the flourishing part of the country due to adequate rainfall. Branches from Allahabad to Fyzabad and ^{Jaunpur} ~~Jyana~~ were added, the first as a military and the second as an agricultural road. The road from Lucknow to Fyzabad was improved. Another important road connected Ghazipur to Gorakhpur with sections to Benares

and Azamgarh. The sub-montane town of Bahraich was joined to Gorakhpur, via Gonda and Basti, for the outlet of their agricultural produce and Mirzapur was connected to Jaunpur. With such branches and arteries we find that the Gangetic plain was well-nigh covered with an advanced system of roads. Two big arteries ran from Cawnpore to link the Trans-Jumna tract with the general road system of the Gangetic plain. One passed through Orai, Jhansi, Lalitpur and was extended south to the Native States, the other passing through Hamirpur joining the Bundelkhand States. After the Mutiny another cross-country road from Banda to Fyzabad was made which joined the Grand Trunk Road at Fatehpur and also passed through the town of Raebareli.

The road from Mirzapur to the Deccan and the road from Agra to Bombay were very important as they carried the bulk of the trade to the south and to the sea-board, though their length in this Province was practically negligible.

The roads described above still form the principal through-communications. Small feeders and the metalled roads joining one part of the district to the other have not been described as they are too numerous to be mentioned. The roads are metalled as funds have become available especially where they act as feeders to railways.

With the advent of the railway since 1847, roads have become a less important form of communication. The bulk of

are
goods and passengers ~~is~~ being carried by the railways.

Within the last 20 years demand for good roads has increased considerably as the motor traffic needs have also grown immensely. Motor traffic has become a menace to the railways because of cheap and unhealthy competition. However, their value as feeders to railways can hardly be over-estimated. Working together a combination of rail-and ~~not~~ motor-traffic is ideal for an Indian province like the U.P.

The history of railway construction in the Province begins in 1847. The East Indian Railway (E.I.R.) Company constructed a line from Allahabad towards Delhi for the first time in the above year, and it passed through many important towns like Fatehpur, Cawnpore, Etawah, Aligarh. A score of years later the Oudh and Rohilkhand Railway Company (O.R.R.) connected the two important towns of the Province. Lucknow was joined to Cawnpore by a railway but the distance between the two towns is less than 50 miles. So far the attempts at railway construction had been made by private companies but in 1875 we see for the first time the government coming to the aid of the people by completing a line between Muttra and Hathras, a distance of about 30 miles. The two companies of Rohilkhand Kumaun Railway and Bengal North-Western Railway were formed in the year 1882. The former serves the submontane districts west of the Gogra connecting them to Lucknow and Cawnpore, and the latter serves the east, connecting Lucknow and Cawnpore to Bengal

through the sub-montane districts east of the Gogra.

The railways are either state-owned or company-owned. The company has a contract to construct the railways and work them for a number of years, after which the whole railway cedes to the state which pays compensation for its cost. The two original companies according to their contracts ceded to the government and were amalgamated in the last decade retaining the name of E.I.R. Different gauges are in vogue in the Province although the standard is the broad gauge and the major portion of the Province is served by it. 5' 6" is the standard gauge but 3' 3" or a metre gauge is also used. For interior communications and for goods service there are gauges of 2' 6" and 2' for the working of light railways. Uniformity of gauge, as is well-known, affords through communication, which the standard gauge of 5' 6" best provides. One can travel from Calcutta to Lahore, a distance of 1,200 miles, without a change. Considerations in the construction of railways have always been trade and commerce, famine relief and the military.

Two trunk lines of the E.I.R. cross the Province in an east and west direction:-

- a. Moghulserai (near Benares), Lucknow, Bareilly, Saharapur section.
- b. Moghulserai, Allahabad, Cawnpore, Delhi section.

These are the two important sections of the E.I.R. which runs from Calcutta to Saharanpur or Calcutta to Delhi joining the N.W.R. at the above stations, for a through communication to the Punjab. The former takes a northerly course whereas the latter takes a direction parallel to the Ganges (up to Cawnpore) on the south side of it crossing the Jumna at Allahabad, after which it passes through the Doab and finally reaches the terminus at Delhi. The northern section connects all the important towns of Oudh and Rohilkhand whereas the southern one connects all the important towns of the Doab with the Punjab and Bengal. Smaller towns not connected with the main line are served by branches to the nearest big towns on the main line to facilitate passenger and goods service.

Three other broad gauge lines pass through the Province. The G.I.P.R. connects Agra and Jhansi with Delhi and Bombay and also Jhansi with Lucknow and Allahabad. A recent branch-line was constructed to connect Banda to Cawnpore as a measure of relief to the famine stricken area of the remaining two districts of Bundelkhand, namely Hamirpur and Banda. The B.B. & C.I.R. connects Muttra to Delhi and Bombay with a branch from Muttra to Agra. The N.W.R. connects the upper Doab districts of Saharapur, Muzaffarnagar and Meerut to Delhi and Lahore and also to Peshawar - the military base on the frontier.

There are three one metre gauge lines working in this Province and a reference to two of these has already been made, but further details concerning them are necessary. The R.K.R. serves the sub-montane districts west of the river Gogra (Sitapur, Pilibhit and Kheri). The main line extends from Lucknow to Bareilly. The B.N.W.R. connects the sub-montane districts east of Gogra to Lucknow and to Bengal with branches to Benares, Ballia, Ghazipur, Azamgarh and to the Nepal border. ^{The} B.B. & C.I.R. serves a small section between Cawnpore and Achnera (Muttra). It closely follows the Ganges till Kasganj where it turns westwards and completes its final stage towards Muttra. Short extensions in Bijnor, Unao, Hardoi, Lucknow and Sultanpur have recently been made.

2' 6"

A/gauge line runs between Saharanpur and Delhi. This is the S.S. Light Railway and serves the western portion of the Upper Doab whereas the main line of the N.W.R. passing through the Province serves the eastern part. Railways on the 2' gauge are almost in all cases meant for the carriage of bulky agricultural commodities e.g. sugarcane. By the end of last year about 6,000 miles of railways were in existence in the Province, but the demand is ever increasing and where the different companies are able to spare funds, they are utilizing them for construction works where there is a pressing need. It can by no means be said that the

Province has a remarkable or a complete system of railways.

It will be of interest to note that the Indian railways have four classes (British railways have only two classes). The first class is usually meant for the high class people, the second class is for the upper middle class, the intermediate class for the lower middle class and the third class for the poor people. This division into four classes brings out remarkably a relationship of the social status of the people to the class in which they travel.

The sub-montane area and the Gangetic plain of the U.P. seem to be fairly well supplied with roads and railways; so that the montane districts and the Mirzapur district in the south-east are the only portions that have remained practically without railways. It is evident therefore that there is no difficulty in transport from the area of production to the collecting centres. The prices therefore tend to equalize and in the distressed areas there is always an abundant supply due to quick transport. The railways to a great extent have led to the decline of road traffic but since the advent of motor traffic the need for good roads is always increasing. So far the roads have been mostly built of Kankar (nodules of concretionary lime) but now there is a demand for tarred or concrete roads. No provincial artery has so far been concreted or tarred, such roads existing only in big towns within the municipal area. The expenses

of tarring or concreting is great and unless the Public Works Department of the U.P. Government floats a loan it will not be possible. It remains to be seen what improvements Congress ministers will be able to make towards the development and extension of good roads. Railways are under the Federal Government.

Railways, as in all other countries, have begun to feel the competition of road traffic but, as has been pointed out before, inter-relation and co-ordination are the best and the only solutions. This point has also been suggested by Jayakar committee on road development (1928). Unhealthy and uneconomic competition should be avoided.

Canals and rivers do take a certain amount of share in the traffic of the Province and heavy commodities like stone, fuel, building materials and metals are transported by water. An appreciable amount of timber is floated down the rivers from Nepal and the Himalayas and carried to the nearest timber market. There is a regular steamer service at Ajodhya on the river Gogra. A considerable quantity of timber, building stone and saltpetre is carried on the Ganges from Mirzapur, but the quicker means of transport has dealt a heavy blow to the river-borne traffic.

Cawnpore, Allahabad, Agra, Jhansi and Lucknow have all been equipped with aerodromes. The former two towns are served by Imperial and National Airways. The airways have

not helped to any appreciable degree the carriage of goods, but the passenger and the mail service has gone a great way towards the development of trade relations between this Province and the other countries of the world. It will not be out of place to remind the reader that one type of transport cannot benefit greatly any country but that co-operation of river, road, rail and air transport will be of far greater service and ideal especially for the Province under enquiry.

The predominance of large towns in the west and also the high improbability of relieving rural congestion by immigration and finally the relation of migration of population to food supply and its importance to the subsistence of this Province has been made the subject of discussion.

Instead of furnishing dry statistical tables, some 4 or 5 maps have been made which, it is hoped, will clearly impress upon the mind of the reader the distribution of population and towns, the density of population per square mile and the increase or decrease of population in the last 20 years (1891 - 1911).

The density in the British V.P. is 450 per square mile whereas that of the North America is 200.

POPULATIONCHAPTER VIII.

It is proposed in this chapter to give a brief discussion of the population of the U.P. At the outset correlation has been established between the density of population and rainfall. The same holds true where lack of rainfall has been counteracted by increased facilities for irrigation. A study of the chief reasons why a heavy density has been established in the east of the Province has been made as it affords an interesting scheme of study. The predominance of large towns in the west has also been made a subject of statistical study. The influence of big industrial centres on the migration of rural population, the high improbability of relieving rural congestion by migration and finally the relation of variation of population to food supply and its importance to the cultivating masses of this Province has been made the subject of discussion.

Instead of furnishing dry statistical tables, some 4 or 5 maps have been made which, it is hoped, will clearly impress upon the mind of the reader the distribution of population and towns, the density of population per square mile and the increase or decrease of population in the last 50 years (1881 - 1931).

The density in the British U.P. is 456 per square mile whereas that of the Native States is 203, the general density

of the total U.P. being 442 per square mile. The reason why the density in Native States is less than half of what is known as British Territory is easy to understand. The state of Tehri lying within the mountainous zone of the Himalayas has a large area where level land for agricultural pursuits is limited and transport facilities are ill-developed and backward. Hence there is a low density. However, the British Territory comprises the cream of the agricultural land and naturally supports a high density.

A comparison of the density of this Province with other provinces of India will reveal that it stands only second to Bengal and a comparison with other principal countries of the world shows that it far exceeds France, Germany, Italy, China or Japan. England, Belgium and the Netherlands are the only countries which exceed it in the density of population. The parts showing a density of more than 800 are only surpassed by the highly industrialised and mining districts of England.

Table I.

Sub-Provinces or Divisions. Density of Population.

Gorakhpur	755
Fyzabad	573
Meerut	535
Agra and Rampur State	521
Rohilkhand	515
Benares	501
Allahabad	492
Lucknow	487
Jhansi	214
Kumaon	102

This table affords an interesting scheme of study from the point of view of the density of population. Gorakhpur division with the heaviest rainfall supports the highest density of population and is followed by Fyzabad division for the same reason. Then the density takes a sudden jump from the east to west because of the security afforded to Meerut and Agra divisions by the introduction of the most useful schemes of canal irrigation. The results of the tube-well schemes have yet to be seen in the census of 1941. Rohilkhand coming next was dependent on rainfall alone as the Sarda canal was not opened until the latter part of 1928. The effect of this irrigation, the writer is sure, will be revealed in 1941. This is closely followed by Benares, Allahabad and Lucknow divisions and then there is a big gap until the Trans-Jumna tract of Jhansi is reached. The plateau nature of this tract, lack of water supply and communications, high denudation and ravining by the rivers

and rainwater have all resulted in the low density of 214. Kumaun division situated within the high Himalayan ranges with lack of culturable land and transport facilities and thick growth of forests is but naturally expected to show a low density. We are now in a position to appreciate that rainfall and irrigation are the two important limiting factors for the density of population in the plains of the U.P. Thus a correlation between the amount of food supply and density of population is at once established in the case of an agricultural area like the one under inquiry. It is also interesting as a clear-cut case of a geographical factor controlling and determining the density of population.

Coming to the actual distribution of rural population in the Gangetic plain, we find that the density of rural population decreases from east to west (see rural density). Here of course we do not take into consideration the montane, sub-montane or the trans-Jumna tract which have much smaller densities due to physiographical reasons. The reasons for the higher concentration of the rural masses can be ascribed to (a) climatic (b) social (c) historical and (d) economic reasons. ⁽¹⁾ A study of climatic conditions along with irrigation has already been made in the last paragraph. A study of the other factors will explain the causes leading to the high concentration in the east. A glance at the Census

Report (1931) will show the predominance of the lower castes

in the east and that of the higher castes in the west, the latter characterised by higher social laws which prohibit early marriages, widow re-marriages or marriage outside the caste, thus definitely retarding the growth of population. The dowry system among the high castes reduces the number of marriages and hence results in a lower density. In the writer's own village situated in the west (Dt. Aligarh) out of 12 families of Brahmin cultivators residing there, no less than 4 young men are bachelors not because of choice but due to the evil effects of the dowry system.

Coming to the historical aspect of the question we find that the east always enjoyed a comparative safety from foreign attacks hence there was a natural tendency towards growth of population. This is also exhibited in the presence of scattered settlements in the east and compact ones in the west.

Lastly the east produces more food than the west due to climatic and physical reasons and a ready market in Bengal is available for the export of agricultural commodities. The standard of living however is lower in the east due to the predominance of low castes which results in a greater density. All the above facts explain the predominance of rural masses in the east.

The average density of population for the Province as a whole follows the rural density because 88.8% of the people

of the Province live in the country. Only where the town influence is more than the rural do we find a greater increase in density. Lucknow and Benares, for example, are instances where the density of population increases considerably due to smaller agricultural area and greater influence of the towns. The urban population in such cases greatly helps to increase the density.

It will be noticed from the Census Report that the Province has a little over 35,000,000 acres of average net cropped area and the number of people directly dependent on agriculture is also a little over 35,000,000. This leaves one acre per man, which means that an Indian cultivator lives in a standard which is much below the standard of the average British or^{the} west European cultivator. The poor Indian cultivator hardly gets two meals per day and thousands often get only one meal and are on the verge of starvation. This with attendant ill-health and susceptibility to disease takes a heavy toll of life every year.

Prosperity entirely depends on weather conditions which are of a very variable nature. The eastern Gangetic plain which has a comparative safety from an extreme variability is studded with a rural population which is threatening every day towards over-population. In the western plain where the variability of weather exercises its influence to a very great extent the density is lower, though compensa-

tion of variability of weather in the form of canal irrigation has been established. The effect of the tube-well scheme as explained above, will undoubtedly have showed its influence by the time the next census is taken. Out of the 10,000,000 acres that are irrigated, half are by means of wells and no less than 3,000,000 are irrigated by perennial canal, the rest being by other sources. The reader may with profit refer back to the last pages of the chapter on irrigation wherein the writer has tried to draw a limit in irrigation and rainfall for a successful correlation with the density of population.

With regard to the distribution of towns (see TOWN MAP), it is seen that the Province under inquiry has a long list of important towns and can boast of at least 8 with more than 100,000 population. Before studying the map it should be noted that towns with less than 20,000 inhabitants have not been included for fear of overlapping although any unit with more than 2,000 people is a town in this Province. It is clear from the map that the western part of the Province is studded with towns of all dimensions whereas the eastern part is not. The reason is mainly an historic one as has been said above, but the influence of the rivers is no less e.g. Hardwar, Muttra, Meerut and Bareilly owe their importance as strategic military centres. After the development of the canals, important collecting centres sprang up like Hathras, Khurja,

Chandausi and Hapur which have become important markets for the agricultural produce. The facilities in road and railway traffic also helped a good deal in the western part for the quick rise in the number of towns. It has not been possible to show in this map the nature of settlement but a study of one inch or half inch to a mile map of the Survey of India will show the following types of settlement:-

1. In the Montane area settlement along the river courses is most common; the cultivator's land lies near the river courses but the houses are situated above where flat land is available. Scattered settlement other than this is dependent on water supply, soil and access to grazing areas.

2. In the Sub-Montane area, the newly cleared forest areas where the drainage of the land does not produce ill-effects are the chief centres of settlement. Nearness to the streams is avoided and the uplands or the doabs above the flood-level are preferred.

3. In the Gangetic plain wherever water and level land is available settlement grows. Uplands above the flood level are the sites of houses.

4. Highly eroded lands/are left as unfit for agriculture and hence/settlement . The plain region with a north-ern slope is generally used for settlement. The question of water supply is very important for the selection of a site for settlement. The introduction of recent canals has

caused a great re-shuffling of settlement.

It will be clear from the statistical tables of the Census of U.P. that during the past 50 years, the urban population of the Province has increased by 15.7%, but the biggest increase was recorded in the last decade when the percentage increase of the urban population was nearly double that of rural. Substantial increases were found in towns between 50,000 and 100,000. This was really due to the influence of commercial and industrial developments. Under the influence of hydro-electric power it is expected that the towns of the western U.P. will expand more when the development of agricultural industries will be seriously taken up due to cheap energy that is available - as substitute for coal.

In the Ganges-Jumna doab, there are a number of important towns which lie in the centre of the doab. All the important towns lie in ^a straight line drawn from Saharanpur to Aligarh. The line passes through the centre of the so-called 'upland doab region'. This fact brings out important geographical factors in the formation of towns. The selection of residential sites had first to be made far away from the extensive Khadars of the above rivers for two-fold reasons, viz. (a) annual floods and (b) predominance of a sandy belt near the rivers. The first factor concerned the personal security of the people but the latter

concerned their activity as the infertile sandy belt did not produce good crops in the ordinary way and which, only with the help of manure and heavy irrigation, could produce a crop. Such soils have only been partially brought under cultivation after the advent of canal irrigation but the location of the towns dates hundreds of years before the canal irrigation.

The Province cannot boast of highly industrial towns in the European sense. Cawnpore, Agra and Moradabad are the only towns which owe their importance to industries. The first is a highly industrialised town and is known as the Manchester of India because of the location of textile industries. It is also a centre for woollen and leather industries. It is the wheat and cotton market for the Province. The last named town has developed an industry of electroplated brassware which is said to be so fine that Moradabad electroplated articles are sold from Kashmere to Madras and from Punjab to Bengal. The workers for the mills and factories of the above towns are drawn from the rural masses which are mostly unskilled. They are first brought to the factories as raw workers and are trained there. They do not adopt industry as their permanent occupation for they temporarily migrate to the industrial centres returning to their holdings at harvest time (1).

(1) Report of the Royal Commission on Labour in India,
1929 - 31, p. 12.

This therefore does not release the rural congestion and the burden on the soil remains the same. Though it is quite true that the rural masses are drawn towards other industrial centres outside the Province e.g. the docks of Bombay and Karachi, the jute mills of Calcutta, the tea gardens of ^{Assam} ~~Assam~~ the character of the migration is of a temporary nature since they return to their holdings at harvest time.

Emigration of landless labour to countries outside India may to some extent release the pressure from the soil, but the economic competition and colour are two great factors of which the white 'bosses' are afraid. Cheap Indian labour and the supremacy of a dark race can never be tolerated by a white nation, hence the laws preventing immigration by darker races have been enacted in foreign countries.

Indians, as a whole, are averse to emigration. The native Indian does only when he is sure that there is nothing for him in his native place to live for and when he is surrounded by trouble on all sides. The Report of the Royal Commission on labour in India has pointed out that "emigration has always arisen mainly from the difficulty of finding an adequate livelihood in one's own native place and this is the predominating force which impels the Indian villagers to seek industrial employment. Over large parts of India the number of persons on the land is much greater than the number required to cultivate it"(1). As we have

(1) Op. Cit. p. 14.

seen above, it is not possible for an Indian to migrate to foreign countries and he has therefore to remain within the boundary of his country. The only possibility of migration is from one district to another or from one province to another.

This Province, like all other provinces, has a huge mass of landless labour which has no work during the greater part of the year. The men work during the sowing or harvesting season or during the period when irrigation is in progress or when labour is needed for the intercultural operations in the sugarcane fields or the picking of cotton. When they are unemployed, they lead the village cattle for grazing to the distant grazing areas or cut the grass in the outskirts of the villages and take it to the nearest town to sell, a process which hardly fetches sufficient to keep body and soul together. They mostly live on the verge of starvation.

Within the last decade the urban population has increased from 10.5 to 11.2 per cent or an increase of 0.7 per/cent. This increase in urbanization was due to increased facilities for commercial and industrial developments, but was accompanied by no decrease in rural population pressure. This goes to show that any slight increase in industrialization will not relieve congestion from the rural masses and if any release is to be attained it should be

looked for in other directions. The effect of hydro-electric power initiated within the decade can only be estimated after the results of the next census are declared.

It will be interesting to note that one-third of the urban population lives in towns of 50,000 and over and half in towns between 50,000 and 5,000 and the remainder in towns of less than 5,000 people. The towns of over 20,000 people in the western U. P., where cheap energy is available, are capable of industrialization and hence it is hoped that expansion of such towns may release the agrarian population to some extent. This release can only be effected in the western districts. There are schemes for providing cheap energy to the eastern districts and unless these schemes are realised there seems to be no solution for reducing the rural pressure.

The last decade showed an increase of population, but the decades ending 1911 and 1921 both showed a decrease due to famine and epidemics in 1911 and due to epidemics and the Great War in 1921. Comparative freedom from epidemics and the aftermath of the War caused the increase in the last decade.

From 1881 to 1931, the Province shows a net increase of about 4,500,000 people or 10.6 per cent. An increase of a little over a tenth of a million is noticed in the Native States which indicates an increase of about 9.7 per cent

within the same time. The whole Province shows an increase of population with a few exceptions. The greatest increase is shown in the hill districts (see map showing increase and decrease of population), an increase due to (a) constant northward penetration by the plainsmen and consequent clearing of forests for the use of agriculture, ^{and (b) healthy + vigorous climate.} The next big increase is shown in the Doab districts of Meerut and Bulandshahr due to facilities for canal irrigation afforded there. The submontane districts east of Gogra show a similar increase due to the clearing of Tarai forests and bringing under the plough the fertile virgin soils.

A decrease is shown in the three eastern districts of Azamgarh, Ghazipur and Ballia. ^{In the absence of any special} ~~because of high density of~~ ^{reason, it would seem that a limit in density of} population has ~~already~~ been reached there. Populations migrated to the neighbouring districts of Gorakhpur and Benares which promised them better conditions. The same is true of Farrukhabad and Unao districts which had reached the limit of ~~the~~ cultivation and hence could not afford an increase. Hamirpur and Banda districts have a lot of denuded, ravined and unfertile soils, the result being a decrease. The biggest decrease is recorded in the Native State of Rampur and the hilly tract of Nainital because ~~the~~ ^{of unhealthy conditions in the sub-Montane zone of the TARAI and} ~~predominance of the BHABAR and Tarai zone which have not~~ ^{BHABAR, and also because,} ~~irrigational facilities are not afford-~~ ed to them. Muttra lying in the ravines of Jumna also

Description of the figures of density
of population shown in the
land use map. (No. 53.).

The figures arrived at in this map are based upon Sinha's idea ⁽¹⁾ of dividing the villages into three categories ⁽²⁾ according to population. The villages were roughly counted on the half inch maps within a certain area and thus the total population determined within that area. Dividing the population by the area, density per square mile was determined.

Though not much use as a method, still it roughly gives a fairly correct generalised idea of the density of population. The half inch maps on which the figures were worked out belonged to the last decade, hence the change of density within this decade shall not be expected to be shown on this map. The only important value for these figures lie in the fact that relief, land forms and soil have played their parts in forming the density of population shown on this map.

Before any attempt is made to describe and substantiate a correlation of density with relief, land forms and soil, it should be noted that there are no figures above the 1000 feet contour. The explanation lies in the facts (a) hilly nature of the region and consequently preponderance of scattered hamlets (b) abundance of small villages with a population of only forty or fifty persons, and (c) migratory nature/

nature of the population within the area. All the above facts combined together, make it almost impossible to assess a correct valuation of the density of population. No attempt was therefore hazarded and the hilly portion was left out for the purposes of the present map.

A study of the figures of density will reveal that the following regions can be easily discerned:-

- (1) Ganges - Jumna Doab
- (2) Ganges - Gogra Doab
- (3) Trans - Gogra Tract
- (4) Trans - Jumna Tract

In the Ganges-Jumna Doab we find that the average density is between four hundred and six hundred and fifty persons per square mile. The density falls where the alkali patches have eaten into the cultivated soils or where the ravines of Jumna are highly pronounced. In the Ganges Khadar (lowland) again we notice an appreciable fall due to insecure position of land and property caused by a constant fear of liability to flooding. In the tract embraced within the province lying south west of the Jumna we do not come across a density of over four hundred and fifty and within the ravines the figure falls as low as two hundred. The former figures (or to be more correct between three hundred and fifty and four hundred and fifty) is only noticed where the land is under the plough and falls to latter figure where the/

the conditions of life are much more vigorous due to a constant washing away of good soil from the ravines. In the main Doab (upland) where irrigation facilities have been afforded due to canals we notice a big rise in the density and it is in this tract that a maximum of six hundred and fifty for this region is attained. In the canal areas usually the density is in the neighbourhood of five hundred.

In the Ganges-Gogra Doab, the first thing that strikes on the map is an increase of density from west to east, the minimum of the west being about three hundred, and the maximum of the east being about twelve hundred. The chief factor governing the density is soil. In the west the soil is from sandy to light loam, and heavy soils form a very negligible percentage. The result is although not much waste land due to alkali but only poor crops grow due to light nature of soil and lack of irrigation facilities. Within the last five years Hydro-electric tube-well irrigation is greatly in progress but the result of which can only be determined in the next census. In the central part of this Doab the figures for density rise to seven hundred, eight hundred or even nine hundred, falling again to three hundred and fifty and four hundred where alkaline deposits encroach upon the soil hindering cultivation partly and sometimes rendering fields altogether unfit for cultivation. Irrigation in this region/

region is effected by canals as well as wells - canals being only recently introduced. In the eastern region where the soil is fertile and the rainfall is sufficient to grow crops without aid to irrigation and where well irrigation has reached a very high standard for the use of spring crop do we notice the highest density. It is in this part that the stress of density is as great as in any highly industrialized part of the world, the figures reaching as high as twelve hundred persons to the square mile.

In the trans-Gogra tract or the land north of the R. Gogra, the density again increases from west to east. In the western part the cultivable area is very limited and is mostly given over to forests where the density is between three hundred and fifty and four hundred, whereas in the cultivated areas it rises to between five hundred and six hundred and fifty, and at places is as high as seven hundred and fifty or eight hundred. The northern fringe of the whole trans-Gogra tract is covered over by Tarai forests where the density varies between two hundred and fifty and four hundred. In the eastern part of this tract where sufficient arable land is available the density goes over a thousand. This tract is renowned for the fertility of its soils; the soil is mostly loam and light clay and at places (see soil map) has been covered over by a deposit of recent sand rich in calcium. This newer alluvium has a special fertility due to/

to lime deposits which fact has been thoroughly dealt with on the chapter on soils. A sufficient rainfall extending over a longer period (late September and early October - rains due to retreating monsoon) together with the nearness of sub-soil water are also important factors governing the crop production of this region and thus leading to a high density of population.

In the trans-Jumna tract or the land south of the R. Jumna comprised with this province, the density falls appreciably as a result of diminution in the percentage of arable land. Mostly the land is uncultivable waste and partly under forests (mostly stunted xerophytic trees). Quite an appreciable amount is given over to grazing. Within this waste and forested area the average density is between one hundred and one hundred and fifty rising to two hundred in the arable land and falling to forty or fifty in the highly forested areas. It is only in the cultivated land between the R. Betwa and the R. Jumna that a density between three hundred and four hundred and fifty is reached, because the conditions here approximate to that of the Gagetie plain. At places where the streams have cut gullies, the density falls to about one hundred and fifty. Further east in Hamirpur and Banda districts (longitude 80° - 81° E.) the density nowhere seems to rise over one hundred and ninety. The chief factors governing such a low density are lack of arable land, excessive ravining, uncertain rainfall and inadequate irrigation.

AGRICULTURAL REGIONS.

CHAPTER IX.

An attempt is made in the following pages to divide the Province into well-defined regions based on relief, climate, soil, crops and density of population. The importance of irrigation has not been overlooked as irrigation has mitigated the effects of poor or irregular rainfall. The rainfall, as is well known, is mostly confined to the period June to September, hence the importance of irrigation can hardly be over-estimated. Population density gives the best indication of the agricultural regions of a locality. A population of over 600 to the square mile in an agricultural region like the province under inquiry indicates a high standard of agriculture and similarly below 200 proves a poorer condition of agriculture due to any or all of the determining factors. It has not been the aim to base the agricultural regions on crops alone as they do not indicate the true state of agriculture. A crop which does not grow in a locality due to some negative influence (e.g. of relief, climate or soil) may grow when that ~~negative~~ influence is removed. Frequently a proper study of the negative influence is not made at all and any difference due to such influences are not realised until after a critical examination. The following agricultural regions can be discerned:-

1. The Himalayan.

2. The Sub-Himalayan.

(a) Siwalik.

(b) Bhabar.

(c) Tarai.

* 3. The Gangetic P lain.

(a) Wheat Region (Canal irrigated tract)

(b) The Transition Zone (Mixed zone of dry and wet crops)

(c) Rice Lands (Tract of permanent masonry wells).

* 4. The Trans-Jumna Tract.

(a) Bundelkhand (Region of black and red soils).

(b) East Satpura Region (Hilly region of the south east).

Himalayan Region:-

A study of the agricultural conditions consequent on the operative factors is a convenient way of describing an agricultural region. The 5,000 feet contour limits the southern extension of the region, but no limits can be set towards the north. The region comprises the inner and outer Himalayas. There is a characteristic change in the vegetation, climate and relief from the plains. Mostly they are wooded to the ~~top of the~~ summits and the chief income to the state is from the forests. It is a region of high peaks and consequently ^{deep} ~~high~~ river valleys. The inner Himalayas is the region north of the snow covered ranges. Agriculture in this region is only represented

* These regions have been further subdivided, the description of which is given at the end of the chapter from pages 288(a) to 288(d)

by cow herding during summer, the hillmen coming from the outer Himalayas for grazing facilities. In winter, when it is a region of snow and nothing else, they migrate to their homes. The outer Himalayas rise abruptly from the foothill zone to 11,500 feet, and the valleys are wider than in the inner Himalayas. The streams themselves are of a permanent nature. Rainfall in this part is very high, e.g. from 70 - 95 inches as compared with 40 - 50 inches in the inner Himalayas, the reason being that moisture-bearing clouds empty themselves on the outer Himalayas before they reach the ranges of the inner Himalayas. The vegetation in this zone is dependent upon height; up to 6,500 feet a tropical vegetation is noticed; up to 11,500 feet temperate vegetation beyond which is the belt of Alpine vegetation.

Cultivation is practised on hill tops, terraced slopes, and in the river valleys. On the slopes this is shifting cultivation with varying fallow periods. In the future as the population increases this method can perhaps be replaced by more intensive farming. The limiting factor for agriculture in this region seems to be water supply and availability of cultivable land and manure. The alluvial soils of the river valleys are the best in this respect and hence a linear settlement

along the river valleys is noticeable. Rice is successfully cultivated in such alluvial soils though to a certain extent terraces are also used for rice. An ingenious system of irrigation is taken recourse to by the people in the terraces. All the terraces are dyked, the rain water is collected in the top terrace which is left uncultivated. Rice or wheat, as the soil permits, is sown in the lower terraces and water is allowed to come through a hole dug for the purpose from the uppermost terrace which has been hoarding rain water. The latter trickles to the next one and from here the water is brought down to the next and so on till all the terraces have been irrigated in turn.

The upland is irregularly cultivated and presents a slightly undulating appearance. Irrigation facilities do not exist in the hill tops, the result being that the agriculture is poorly developed and only inferior crops such as Mandua or maize are grown. A hillman prefers to grow spices for export as they are not heavy commodities for, in the absence of good transport facilities, it becomes difficult to carry bulky produce to the market for disposal. The climate is ideal and is suited for tea cultivation, Dehradun being the chief tea centre.

It is the availability of land for cultivation that governs settlement in the Himalayan region and the density is determined by the fertility of the soil and water supply.

Height to a certain extent also determines the settlement as can be evidenced from the fact that the 5,000 feet contour is flanked with numerous prosperous villages, above which patchy settlement is visible with the villages far removed from each other. Settlement is favoured by flat spaces with good soils in the river valleys for cultivation and access to grazing areas for the cattle.

The mean density of population in this region is 109 to the square mile. But such an average has little meaning in these mountains. It is interesting to note that population is migratory and is centred round the hill stations which afford ~~work~~ and protection against the adverse summer heat of the plains. During winter the plainsmen come down and the hill stations are deserted.

The Sub-Himalayan Region:-

This is the region of foothills between the Gangetic Plain and the lower slopes of the Himalayas up to 5,000 feet. Rainfall is fairly heavy and consequently the region is highly forested. The region comprises a highly denuded and ravined slope of the foothills, and gives shelter to the wild animals within its forests.

(a) The Siwaliks:- This sub-region includes the lower slopes of the outer Himalayas, the Siwalik range in the South and a number of longitudinal valleys between these. These valleys are known as Duns and the largest of them is Dehra-Dun. Towards the east of the Ganges the Siwalik ranges are broken, hence the

valleys in the eastern part are not so well defined as in the west.

They are prosperous agricultural areas and have gained a popularity as the fruit gardens of the U.P. The forest clearings are closely followed by extensive agriculture using the supply of irrigation water. The chief crops are rice, wheat, maize, mandua, tea and fruits. DehraDun produces one of the finest qualities of rice and is the chief collecting centre for the rural produce. The crops depend on the height of these valleys. Poorer crops are grown in the higher valleys and the richer on the lower ones. All available cultivable land has been brought under the plough and new forests are cleared as a direct result of extended cultivation. Proper care is being taken to cope with the ill-effects of forest clearings.

Settlement is determined by the proximity to water though nearness to the big streams is avoided because of floods. It also depends on the height (as the crops depend on height) and aspect. Fields with northern aspect are preferred because of their ability to retain moisture longer. In this tract it is mainly the cultivable area that determines the settlement as the houses are built near the fields for the use of farmyard manure.

(b) Bhabar:- This is a peculiar recent formation of boulders and gravel with a very spongy texture and clayey

bottom. It lies within the foothills and in the damp Tarai and is characterised by the absence of water except during the rainy season. The torrents rushing down the mountain are lost beneath the gravel and reappear again in the Tarai.

It was all forested till of late and only recently was the attention drawn towards the possibility of converting it into an agricultural area by clearing the forests. Absence of water and its malarious climate were the two great factors which had to be fought to make it into an agricultural tract. Masonry irrigation canals were introduced to solve the first problem which, though insufficient at present, are, however, a step forward towards its complete reclamation. There can not be a speedy improvement in the problem of water supply as the streams do not give a constant supply of water, not being snow-fed and also due to their ever-shifting nature. It is interesting to note here that the water-table is very low due to the spongy texture and hence the possibility of well construction is out of the question. Excessive heat, heavy rainfall and preponderance of forest vegetation all go to contribute towards its unhealthy climate. The proper utility of the heavy rainfall and shrinkage in the forest area may some day be able to cope with the unhealthy climate. The climatic condition has resulted in a migratory population, the plainsmen entering from the south and the hillsmen from the north only

during the sowing or harvesting time, and returning to their homes after the agricultural operations are over. As a result of this practice agriculture suffers. Sometimes the hillsmen remain here throughout the winter and return to the hills at the approach of summer. In such cases the land gets better care and the outcome is a better return. Settlement of a permanent nature is only resorted to by a tribe known as 'Tharus', who are well known for their power to withstand malarial climate. It is the cleverness and ingenuity displayed by them in the selection of their dwelling-places which makes them able to fight against the adverse and unhealthy climate. They select the upper terraces for their habitations in order to avoid damp, and they insulate the inner wall of their dwellings with a coating of damp-proof material. They also keep their drinking ^{or other} water well covered so that the immunity is largely due to their own skill.

Settlement is governed by forest clearings and damp-proof parts (e.g. the upper terraces of the streams) and the availability of irrigation water. The tract has got all the potentialities of a rich agricultural land but the only problems to be solved are the water supply and the unhealthy and malarious climate.

(c) The Tarai:- This is a land of marsh and fen and slow sluggish streams lying south of Bhabar, and crossing

the Province throughout its entire length and imperceptibly merging into the Gangetic plain in the south. The northern fringe of this region represents a true Tarai character but towards the south the conditions approximate to that of the Gangetic alluvium. Cultivation has extended up to the line of springs which rise in a series of morasses south of the Bhabar. The Tarai is narrow towards the west and broadens out towards the east where it separates the Himalayas from the Gangetic plain. In the extreme west the true Tarai has practically disappeared because of the tendency for extended cultivation.

Rainfall is very heavy due to the nearness of the hills which has resulted in bumper forests and tall grasses. The climate is very malarious and unhealthy due to predominance of these forests and grasses and heavy rainfall but the Tharus are slowly and gradually penetrating northwards and are materially adding to the cultivated area. Valkenburg writes that until recently it was almost an uninhabitable zone but increase in the density of population resulted in a northward penetration (1). The northern part of the Tarai still predominates in the grazing though the southern part has been brought under cultivation where it is covered by smiling, green fields of rice.

(1) Valkenburg, S.V.: ~~The~~ Agricultural Regions of Asia - *Economic Geography* Vol. X, 1934, pp. 16 - 17.

Due to the unhealthy climate the population of the northern Tarai is migratory as in Bhabar. The plainsmen enter from the south in the beginning of November after they have finished their Rabi sowing of the plain area. Their families stay in the plain to look after the crop and they themselves stay in the Tarai to grow a Rabi or for the purposes of cattle grazing and return to their homes before the break of the monsoons as they are unable to withstand the climate.

The forest-cleared virgin soils are wonderfully productive and a continuous sequence of three crops of sugarcane is not uncommon. The chief crops of the Tarai region are rice, wheat, maize, pulses and oilseeds. Sugarcane is an important crop in the forest-cleared areas.

Doabs and their position determine ^{settlement} ~~sugarcane~~ as they are situated above the flood-level of the streams. In the southern parts of the Doabs, agriculture is more important and consequently they are densely populated but in the north grazing is predominant, though a certain amount of agriculture in the newly-cleared areas can be seen. Southern doabs are the scenes of busy agricultural operations and are connected by the B.N.W.R. as the outlet of trade and commerce. Density of population again increases from west to east where it is over 600 to the square mile. A certain amount of agricultural trade is also carried on with Nepal

through the eastern part of the Tarai.

On the whole it shows a high standard of agriculture in spite of poorly developed transport facilities due to innumerable streams both small and large and it is hoped that with increased ease of communication the region will turn out to be one of the most prosperous tracts supporting a heavy density of population.

The Gangetic Plain:-

The Gangetic Plain occupies the whole of the area between the Sub-Himalayan Region and the Jumna and after its confluence the Ganges. More than half the area of the Province is embraced within this agricultural region. It is a transition zone between the Punjab and Bengal (1). The western part of the Province has affinities with the Punjab and the eastern with that of Bengal and a transition zone between the two can be recognised where the intensity of wheat and rice cultivation is fairly typical of the zone. In the east, ^{there is} ~~the water table is high hence~~ the preponderance of masonry wells while the poorer rainfall in the west has necessitated the construction of giant irrigation schemes of canals and tube-wells. In the transition zone we find a mixture of both types of irrigation. Rice is the chief crop of the east and hence we have called it a rice zone and

(1) Baker, J.N.L.: Notes on Natural Regions of India - Geography, Vol. XIV, No. 81, pt. 5, 1927 - 28, p. 452.

wheat is typical of the west, therefore it is named a wheat zone. Between them is the transition zone. On the basis of climatic and soil conditions, irrigation and agricultural practices the following zones or regions are devised:-

1. Wheat tract or the West Gangetic plain - this is bounded by the 30 inches isohyet.
2. Transition zone - this is the area comprised between the 30 inch and 40 inch isohyets. We may call it the middle or central Gangetic plain.
3. Rice tract or the East Gangetic plain - east of 40 inch isohyet.

Western Gangetic Plain or the Wheat Zone:-

From the basis of division it will be clear that the tract receives less than 30 inches of rainfall, ~~the~~ most of which is received between June and September. Poor rainfall and its unreliable nature has made it the most precarious tract from an agricultural point of view. Artificial irrigation is the only possibility on which the region can depend for successful cultivation and this is effected by canals. It is the network of canal irrigation system which is the chief characteristic of this region. Not only has it helped in better farming but has saved it from the constant ravages of distress and famine. Well-irrigation ~~is~~

supplements the canal irrigation in this region.
~~not very successful in the times of low water level.~~

The recent development of hydro-electric power along with the

tube-well scheme has tackled the underground water and the completion of the State Tube-well Scheme has seen the upland region supplied with water where canal water could not be taken against the force of gravity. A change of cropping from dry zone crops to wheat and sugarcane is sufficient testimony to truth of the above statement. As a result of irrigation, the standard of cultivation exhibited is of a very high ~~standard~~. Wheat and barley are the chief Rabi crops, Juar and Bajra take the place of rice in the Kharif. It is also an important producer of sugar and cotton. Millets are grown on the poorer upland sandy soils or the 'tired' land as Lyde (1) calls them. Better soils are given over to the production of important crops like sugarcane, which reach their best development in this tract. Meerut is the centre of sugarcane area. Cotton also reaches its ^{highest} ~~best~~ development in this tract and the centre of the cotton area is the town of Aligarh. The main reason for the importance of wheat is the winter rainfall which this tract receives. It saves the irrigation water and hence reduces the cost of production.

It is this tract which is the most highly-developed cattle breeding centre and also the centre for the dairy industries. This region has a greater density of cattle

(1) Lyde: Asia, p. 382.

than any other part of India, in spite of having very little grazing area. This shortcoming is compensated by the high percentage of fodder grown in this tract.

The easy outlet of the agricultural produce due to an excellent system of roads/^{and railways} also adds to the agricultural prosperity of the region.

Transition Zone or the Central Gangetic Plain:-

Situated as it is within 30 and 40 inch isohyets, it is a region of dry and wet zone crops. Wheat is as important as rice and it is difficult to establish which of the two crops occupies the leading position. Juar and Bajra take the place of rice near the 30 inch isohyet whereas rice easily takes the lead near the ^{40 inch} isohyet. Wheat all through plays an important part but takes the lead at the western extremity. Very little cotton is grown on the western border and none at the eastern border. Cawnpore is the ^{cotton} centre of production. Sugar is not an important crop in this region. However where irrigation is available due to the Sarda canal in the east or tube-wells in the west, it takes the place of dry zone crops. Sugarcane acreage is increasing rapidly due to the aforesaid irrigation schemes. Well-irrigation also becomes important because of a rise in the sub-soil water-level which in turn is consequent on a comparatively higher rainfall.

Having the facilities of irrigation and an adequate

rainfall, this tract contains the largest number of important towns. A wonderfully good system of metalled roads also makes this tract rich in large towns. The position of Cawnpore is worth noticing. It is just a little to the east of the 30 inch isohyet and falls within this region. It acts as a collecting centre for wheat and cotton and hence the localization of cotton industry there.

The importance of the transition zone is manifested in the intermediate position it has taken in all factors operative on agriculture. It has a rainfall between the two extremes for the Province, the highest being in the east and lowest in the west. It grows crops which are a mixture of dry and wet zone crops as mentioned above. It has a system of irrigation which is a mixture of canal and well, representative of the west and east respectively. It has a density of population as well as a system of communication which is approximately between the extremes. This intermediate region fittingly deserves the name which has been ^{to} given/it 'The Transition Zone'.

The Eastern Gangetic Plain or the Rice Zone:-

Rainfall throughout this region is heavy (between 40 - 50 inches). The construction of canals is not necessary for a tract receiving the high rainfall that it does. The Sarda canal protects a considerable area on the west against adverse climatic conditions. It is a protective measure

and not an absolute necessity. Generally irrigation is effected by wells as the sub-soil level of water is higher because of a heavy rainfall. This tract contains some of the districts showing more than 50% of irrigation and in some cases even surpasses canal irrigation.

The whole tract is a region of flat plain below 500 feet, the eastern-most tract being below 250 feet. It is drained by the Ganges and its tributaries, which bring down large quantities of silt and mud. Though the tributaries have built up high banks on either side, they are never free from disastrous floods in the rainy season due to a continuous deposition of silt in the bed and consequent raising of the water level above the surrounding country. Damage to life and property is severe but is more than counteracted by the fertile layer of silt that is deposited and to which the tract owes its fertility. The lowlands are liable to annual flooding whereas the uplands are flooded in years of abnormal rainfall only.

The Trans-Gogra tract has a special kind of soil known as Bhat which contains a greater percentage of calcium than other soils. This is the sugarcane tract of the north-eastern U.P. Wheat, barley and oilseeds are grown on the Bangar or the Ganges - Gogra doab, where the soil is fertile loam or clay. Heavy low-lying lands or the abandoned beds of rivers are the rice fields. These lands have a strong

affinity to the rice lands of Bengal. Maize is also an important Kharif crop. Sugar cultivation of late has been rising by leaps and bounds because of a great demand which can be judged from a sudden rise in the number of sugar factories.

The tract has not got many large towns as it is rural in outlook and small towns suffice as collecting centres. Settlement as has been shown in a previous cross-section is patchy and scattered. Villages consisting of a few scattered dwellings are more common and big villages are the exception rather than the rule. Density of rural population is highest here. This is not because it is a highly agricultural and rural tract but because there is a preponderance of lower castes with the attendant consequences of a higher birth rate. The problem of overpopulation is acute in this region, a fact exhibited in low vitality and poor health of the people. This is also shown by the smaller holdings of the east.

This tract contains a splendid system of roads and railways, but the Trans-Gogra tract is somewhat lacking in railway development but affords an easy outlet for the produce of the country through the help of roads and rivers. The Gogra river still carries a certain amount of river-borne traffic. Benares and Gorakhpur are the main collecting centres, the latter carrying a certain amount of trade with Nepal.

The Trans-Jumna Tract:-

The conditions south of the Jumna and, after its confluence, the Ganges are different from the conditions north of the above rivers. The Vindhya and Kaimur extensions are the ranges of moderate heights which appear in the south of the tract. The plain formed by the rivers rising in the above hills has been dissected and present an appearance of undulating country - a contrast to the Gangetic plain. The drainage of the region is entirely to the Ganges hence the region lies within the Ganges basin. It can be sub-divided into (a) Bundelkhand and (b) East Satpura.

Bundelkhand:- The region comprises dissected areas due to the nature of the rivers which are increased by a network of ravines working their way on the slopes. Ravining increases as a minor stream joins a major one. A careful glance over the Land Utilization Map 1/M will reveal that they are extensive in Jalaun district north of Jhansi. These lands are given over to grazing and the ravine free lands sloping towards ~~the~~ north are used for agriculture.

The rainfall is between 25 and 35 inches, the precarious nature of which had made it the land of famines. After the development of transport facilities and the introduction of canal schemes, the tract has progressed to a considerable extent. Deep water level has inhibited well irrigation. Tank irrigation is still preserved but they too are depend-

ent on a good rainfall.

The alluvial soils known as Mar and ~~Kabar~~ are black ⁱⁿ or dark/colour found on the plain. It is difficult to work these soils due to their composition. The former under normal conditions is a good soil. Deficiency of water does not effect cultivation so much as excess because of the retentive nature of the soil, but the latter is effected either way; excess results in a difficult working due to sticky nature and defect causes cracking with wide gaps. This is the region of unreliable rainfall and hence has been protected by canals. Dry zone crops, e.g. Bajra and Gram are raised but the former soil grows wheat and oil-seeds under irrigation. Rakar is an inferior soil on the slopes of ravines and grows poor crops. Parwa corresponds to the light loam of the Gangetic plain. A red soil formed by the weathering of rocks is visible in the southern part of Jhansi and Hamirpur districts and the fertility of this soil is measured in inches of crumbled rock. Mostly the covering is thin and hence does not retain moisture.

The poor standard of agriculture, nature of soil, limitation of water supply and the rocky outlook of the country have jointly contributed towards a low density of 214 persons to the square mile. Settlement in the north is governed by the character of rivers and fertility of soil but a re-shuffling of settlement is visible in the canal

area. Where lands are given over to grazing, the access to them determine settlement. Village sites are usually far removed from the fields because the culturable land is limited hence contrary to the Gangetic plain the land adjoining the village site is the poorest.

East Satpura Region:- Most of the country comprises lowhill ranges offering obstacles in the way of settlement and agriculture. It is inhabited by primitive people employed in cottage industries of the forest produce, and agriculture is practiced only in favoured localities.

Three sub-divisions are visible (a) bounded by the Ganges on the north and the Vindhyan escarpment on the south (b) between the Vindhyan escarpment and the Kaimurs - the water parting of Tons and Son - lies the extension of Vindhyan tableland and (c) the east Satpura region lying south of the Kaimur water parting.

It is mostly a non-agricultural area, the forest produce is the chief occupation supplemented with patches of agriculture with the help of irrigation. The whole of the Vindhyan tableland is an inaccessible part. In the south where forests have been cleared grazing offers some prospect. Agriculture is only important just south of the Ganges.

Sub-Divisions of the Western Gangetic plain (Wheat Zone)

This region can be divided into the following sub-groups:-

1. The south-west corner of the district of Agra.

The agriculture in this region is very poorly developed due to basic sandstones and thin capping of soil. It is further handicapped by lack of irrigation. Due to higher situation than the surrounding land it is almost impossible to carry water against the force of gravity. Sub-soil water is very low and hence well construction is not possible. This is the rugged, barren tract being the extension of Aravalli Hills.

2. The Doab - between the Ganges and the Jumna.

This is the highly canalized light soiled tract, wheat and cotton are the important crops. Irrigation in nearly the whole area exceeds 40% of the total cultivated land. The smaller Doabs where water cannot be carried is irrigated by wells dug on the alluvium. The river Khadars or lowlands are not supplied with canals because plenty of moisture is always available there. During the dry periods small holes are dug near the river bank. Water oozes out from these shallow holes which is utilized for maturing the Zaid crop (melons, cucumbers and water melons etc.).

3. The small strip of land lying north of the Ganges.

This is the piece of land mostly irrigated by wells. This tract has a better rainfall than the one described above, hence/

hence does not need canals so urgently. The wells are the chief source of irrigation.

Sub-Divisions of the transition zone.

The following regions are made on the basis of irrigation:-

1. The canal irrigated tract divisible into (a) Upper Doab, irrigation for the most part over 40% of the total cultivated land, only in Saharanpur district being less than 25%. Dry zone crops are cultivated for the most part. Rice is cultivated in the north of Saharanpur due to heavy rains. Rainfall usually less than 30 inches (b) Lower Doab - Rainfall is between 30 and 40 inches and irrigation is between 25 and 40%. Higher rainfall reduces irrigation. Mixture of dry and wet zone crops are cultivated. Rice is as important as wheat.

2. Well irrigated tract.

This is the tract between the Ganges and the Ramganga. Rainfall is over 30 inches and irrigation here shrinks to below 25%. Mostly dry zone crop is cultivated.

3. A tract of mixed irrigation of wells as well as canals.

This tract lies east of the Ramganga. It receives an annual rainfall between 35 and 40 inches. Irrigation increases from west to east (from below 25 to above 40%). It grows a mixture of dry and wet zone crops. Rice is the predominant crop in the extreme east, whereas wheat is more important on the western part.

Sub/

Bundelkhand soils, varying in colour from black to light grey. The percentage of sand varies from 29.90 to 53.10 . It is a soil of drift origin as has been discussed before. Dry zone crops are mostly cultivated in this region. Irrigation is below 25%. Rainfall is very precarious (over 22% variability).

3. Red soil region.

It is a very thin soil. It cannot retain moisture for long. Cultivation is precarious. Land cannot stand continuous cropping. Not more than one crop is grown in a year. Irrigation is below 25% as in the above. The soil is not of drift origin, but is covered by a thin mantle of loose crumbled rock materials.

SCOPE OF AGRICULTURAL IMPROVEMENT
IN THE PROVINCE.

CHAPTER X.

Before discussing the question of agricultural improvement it is important to find channels into which the rural congestion can be relieved or some outlet should be worked out for the ever rising population. The Province as we have already studied is primarily an agricultural one, and the chief solution for the congestion and rising population lies in the improvement of its agriculture.

Any extension in the cultivated area is not possible as the whole of the 62 per cent of the available land is under cultivation. 17 per cent is under grazing and any diminution in the grazing area will mean deterioration in the cattle which is the prime motive power for the agricultural operations of the Province. 5 per cent is under forests, *almost entirely away from the plains* the clearing of which involves the risk of surface drainage and lack of fire wood, and will ultimately turn into ravines if cleared. 8 per cent is under building, roads and river courses and the remaining 8 per cent is barren land.

There is no prospect of relieving the rural congestion by urbanisation as the increase of 0.6 per cent in the ratio of urban to rural population during the last census decade has not materially helped. Besides there is no tendency for urban life in the absence of big industries.

Lack of minerals is the chief limiting factor for the industrialization of the Province. Hydro-electric however, or 'hydel' as it is called by a recent commission, is partly meeting the need for coal by facilitating smaller industries but the fate of the heavy industries is sealed because of the lack of mineral resources.

Migration is very limited whether it be to the tea plantations of Assam or the jute factories of Calcutta, the dockyards of Bombay or Katachi or the mines of C.P. Mostly migrations are of a temporary nature and very few settle down in those parts. Seasonal migration within the Province, e.g. to Bhabar and Tarai, will not relieve the congestion.

When we are not able to find suitable channels to relieve the rural congestion, the only possibility before us is to improve the agricultural conditions and afford them all possible help to assist to build up a state of agriculture that will be able to utilize its growing population.

Surface Drainage:- In a tract like the U.P. where the rainfall period is short and the fall is not confined to slow showers but occurs in heavy downpours, a first question of agricultural improvement is how best to utilize the rainfall which merely goes to waste. Not only is the rainfall wasteful, but the gullies and ravines caused by the movement of water towards the drainage channels diminishes the

agricultural area, these waste areas producing nothing save a crop of grass during the rainy season. Thousands of acres of lands have thus become barren on either side of the river Jumna. A village situated within a once flourishing area on the bank of Jumna is surrounded by ravines to-day.

At first sight, the only possible proposition seems to be irrigation by which the drained water can be led to the fields, by controlling the rivers, damming them and constructing canals. A great deal can however be done without having to put in such heavy outlays as the canal projects. The regulation of the 'run-off' or surface drainage is as important as canal schemes. It is during the heavy monsoon falls that the regulation of run-off is important because it is at that time that the surplus water does not get a chance to soak into the soil and runs off to the rivers and other drainage channels carrying with it the fine soil particles and a large amount of organic matter leaving the country barren from the point of view of crop production. The ravines on the banks of the Jumna in the districts of Etawah have been taken over by the Forest Department for its successful experiments in afforestation (1). The damage done by scouring in the ravine area is too great to be combatted by afforestation only. Howard suggests "the remedy

(1) Smythies, E.A.: Afforestation of the Ravine Lands in the Etawah District, United Provinces, Indian Forest Records, VII 1919, p. 217.

in cases such as these is simple. A system of embankments, provided with spillways, is all that is needed in the worst cases of denudation" (1). A drainage survey of the sub-montane districts between the Gogra and the Gandak has been strongly recommended in the report of the sugarcane committee (2). A drainage survey on the basis of drainage maps which can be drawn on the spot will, it is hoped, greatly improve the agricultural condition of the soil. These maps will be handed over to the engineers who are conversant with the agricultural problems and who will undertake all such improvement such^{as} the building of roads, railways, canals, embankments, etc. without any importance to crop production.

Irrigation:- By the completion of the Sarda canal, nearly all the rivers that could lend themselves to the construction of canals have been tackled for purposes of irrigation. No more extension of this source of irrigation can be looked for. What is more important than the cutting of canals is the judicious use of the canal water.

The first thing that strikes a visitor in the canal colonies is the extreme waste to which the canal water is subjected all round. This has been going on for years, nay

(1) Howard, A.: Crop Production in India, 1924, p. 15

(2) Report of the Indian Sugarcane Committee, Simla, 1921.

decades and the result is that canal colonies have become water-logged. Alkali infected land can be traced from Meerut as far as Cawnpore running parallel to the canal.* The reason is that the land nearest the canal is more susceptible to water-logging. This is a waste of good land which is a serious drawback to a rising population. It requires much expenditure to improve such lands and whether such improvement has permanent efficacy is still doubtful. The cultivator has learnt by experience that extra water mitigates the effect of bad cultivation and as he has not to pay by volume of water used, he does not care how much water is wasted. Recent experiments at Shahjahanpur Farm have shown a yield of 36.5 maunds of wheat per acre from a three acre plot after sugarcane. The wheat crop was sown with the natural moisture and was ripened by only one irrigation. Experiments in^{the} Punjab, Sind, Baluchistan and U.P. all showed an increase of yield with one irrigation though the seed was sown in all these cases with irrigation. The second irrigation after sowing led to a decrease in the yield (1). When the cultivator irrigates his fields by well water, he is very cautious to use the necessary amount of water and no more as any extra water will mean a higher cost of production. He also adjusts the cultivation of his fields to a

* See 1/M Land Utilization Map.

(1) The Saving of Irrigation Water in Wheat Growing, Bull. 118, Agr. Research Institute Pusa, 1921.

nicety for the simple reason that well cultivated fields require less irrigation water. If, therefore, the canal water is sold by volume instead of per acre, a desired economy in irrigation water can be effected and this extra water can supply the tail-end of the canal which often runs dry. Thus a greater area can be commanded than at present. Irrigated fodder like Bersee or Lucerne can be grown with the extra water.

The system of tube wells is to be highly recommended. By the end of 1937 there will be 1,500 tube wells in the Province. In the 8 western districts of the U.P. sufficient improvement has been made in tube well irrigation. In the eastern districts where cheap electrical power is not available, tube wells can be worked by oil engines, probably the cost of working will be higher than the electric tube wells but, in any case, it will come out cheaper than the cattle-lifted water. All the uses and advantages have been dealt with thoroughly in a last chapter on irrigation, therefore it is not proposed to make further mention of the utility of tube wells, but the installation of tube wells can be highly appreciated. The greatest defect of a tube well comes in the form of high initial outlay. Co-operative irrigation societies when formed will go a long way to remedy the factor of cost. The amount of water raised, the utility to the crops, loss by

evaporation and transit and effects towards improvement or deterioration of soil are all simple matters and can be studied by the co-operative irrigation societies. Co-operative tube well irrigation is the urgent need of the Province and if any extension of agriculture can be looked for, it is through such societies. Agricultural development over and above the tube wells can also be effected by ordinary spring wells. The limit to the sub-soil water has not yet been reached and hence any extension towards irrigation can also be looked for, on the building of wells to tackle the inexhaustible supply of sub-soil water (1).

Alkali Problem:- Intimately associated with the problem of water supply is the problem of alkali land in the U.P. The improvement in agriculture on the lines of reclamation of alkali lands is not an easy matter to be effected. Though the importance of this problem has been recognised for many years and much time and money have been spent on its solution, the results obtained so far are far from satisfactory. At least the problem has created wide interest among the workers and has also put before them the stiff nature of the job.

The presence of salts in injurious quantities on the surface of the soil in the form of snow-white or brownish-black colour is the result of lands suffering from alkali

(1) The Trend of the Agricultural Development in the U.P. - H.M. Leake, A.J.I. Vol. XVIII.

The former contains sulphate and chloride of sodium whereas the latter contains carbonate of sodium in addition.

Hilgard (1) believes that the carbonate is formed from the sulphate and chloride in the presence of carbon di-oxide and water, and the action is reversed in the presence of oxygen. The former type of alkalinity does not effect the land so badly as the latter.

Directly, the alkali is not injurious to the growing seedlings or micro-organism of the soil in mild quantity but when the salt ~~ix~~ incrustation is strong, the water from the roots of the seedlings passes out readily to the salt solution outside by osmosis. The osmotic pressure of the root cells has got to be considerably greater than the soil solution for the opposite reactions.

Alkalinity is prevalent on stiff, heavy and poorly aerated clays whereas the open soils are notable for the absence of alkaline patches. The latter soils can suffer from alkaline only when there is a Kankar bed in the sub-soil which has been obstructing the drainage. The accumulation of stagnant water on a clay soil may also cause alkali formation. Experiments in Mesopotamia have proved the above facts beyond doubt and there seems to be a close connection between poor aeration and alkali formation (2).

(1) Hilgard, E.W.: Soils, New York, 1906.

(2) Webster, J.F.: Alkali Lands in Iraq, Memoirs 1 & 5, Dept. of Agriculture, Mesopotamia, 1921 & 1922.

The tendency towards alkalinity caused by poor aeration can be brought under control by maintaining the texture and permeability of the soil.

A permanent benefit is brought to the alkali lands by the addition of organic matter where it is obtained in great quantities, e.g. Aligarh. Deep-rooted fodders like lucern help the soil where the land has been slightly affected by salt. Addition of gypsum (sulphate of lime) converts the black alkali into the less harmful variety. In some cases the mixing of alkali soils with sand also does some good. The universal method of sub-soil drainage failed in this Province either because the drains were silted or they did not function properly because of the impermeable character of the alkali soil (1). Dhar in his numerous articles in the Indian papers has urged the reclamation of alkali infection by the application of molasses (a by-product in the manufacture of sugar) .

All the above means help but little towards the reclamation of Usar soils. It is only in mild cases of attack that they prove of benefit. More important than the reclamation is the investigation of the cause of the infection and once the origin of alkali is understood, the solution is in sight. The next attempt will be to remove

(1) Howard, A.: Crop Production in India, 1924, pp. 45 -46..

or set right the causes that have led to the formation of alkali. Then perennial irrigation will not be an experimental thing but will be based on experience. Canals will be cut where the soil aeration is properly maintained and clays do not abound or where the drainage is not obstructed by the presence of a hard pan in the sub-soil, or where soil conditions are liable to be disturbed by the introduction of canal schemes. Schemes such as drainage will closely follow the canal projects. Such investigations and studies have been very useful in the Sarda canal project which has taken due consideration of the drainage schemes because of the heavier nature of soils in Oudh.

Nitrogen Problem:- After a careful study of the water distribution problem, the next step to be taken towards the development of agriculture in the U.P. is the solution of the nitrogen problem. Irrigation facilities without a due regard to the need for nitrogen will not be of great help. In the development of Indian agriculture the supply of water and nitrogen should go together to bring about happy results.

The nitrogen problem can be tackled in two ways viz. (a) by reducing the losses of nitrogen, (b) by increasing the nitrogen content of the soil. The loss of nitrogen is caused in many ways. In the first place one of the most serious objections to the burning of cow-dung is the loss of nitrogen. Before this practice can be stopped, the

cultivator has to be supplied with sufficient wood for firing so that the soil fertility may not be wasted but may be directly returned to the soil. Secondly, a quantity of soil fertility is exported in the form of oil-seeds and other food products, animal produce, bones, hides and in various other forms. The loss of nitrogen due to export has often been greatly exaggerated by the different workers on this line. Even Voelcker is not free from such pessimistic views. (1) Leather⁽¹⁾ has proved ~~that the influence of export on the fertility of the land is very little.~~ ^{That} Whatever loss of nitrogen is caused, the soil is more than recompensed by the addition of nitrogen to the soil annually brought down by the rainfall. Besides, it is not a sound policy to stop the export trade as that would induce an economic crisis. Cultivators will be reduced to poverty and as long as the dues are paid in cash, nothing should stop the export trade. Finally water-logging during the rainy season entails an important loss of nitrogen to the soil. Loss from this source is considerable and can be largely avoided by maintaining a system of surface drainage as suggested earlier in this chapter. Determination of the system of surface drainage will depend on local conditions.

The next factor is how best can the nitrogen content of the soil be improved to bring about increased yield or to

(1) Leather, J.W.: A Note on the Composition of Indian Soils, the Agricultural Ledger, 1898, No. 2.

change the present system of farming from extensive to intensive. The 'town circles' have already started intensive farming as nitrogen supply is found in abundance in the form of sewage or city refuse in the town areas. Where such form of ready manure is not available the use of nitrogenous fertilizers such as sulphate of ammonia and saltpetre should be freely encouraged. Both the above fertilizers are manufactured in India, but it is a pity that they are not applied to the Indian soil; instead they are largely exported to Java and elsewhere. The price of these should be brought down to such a level that it should be well within the means of the average intensive farmers to use them to a large extent. Oil cakes should be used on the soils to a greater extent than at the present day. Land should be rested as often as it needs and the full play of the soil organisms should be encouraged. Rotation with leguminous crop should with profit be practised. The nitrogen bacteria working in the root nodules of the leguminous plant helps in fixing the atmospheric nitrogen. Wherever the cultivators have a chance of growing wheat, cotton, sugarcane or oil seeds, they grow them because they mean money. But the inclusion of legumes in rotation plays a very important part when the soil has reached a lower standard of fertility or has started showing signs of nitrogen hunger. When the virgin soils of the Tarai were

first brought under cultivation, cash crops year after year were produced with the result that the soils became exhausted and the yield was reduced. It was only then that due attention was paid the nitrogen problem of these soils. Green manuring with leguminous plants is of the utmost importance for a crop like wheat where other organic manure is not available in plenty. Sann-hemp (*Crotalaria Juncea*) has proved of great benefit in the light open soils in the alluvium (1). It can therefore be safely recommended for the western districts of the U.P. where the soils are of a light nature.

Though a certain amount of composting is being done in the Province, a great lesson can still be learned from China and Japan where the technique of compost-making is of very high standard. The Indian composts are often not in a readily available form whereas great care is paid in the far East to the right stage of decomposition of the manure before it is applied to the fields (2).

It is gratifying to be able to record that a beginning on the above lines of nitrogen improvement in the soil has been made at Shahjahanpur and a great deal of work has been done with regard to crops like sugarcane and wheat etc. It

(1) Dobbs, A.C.: Green Manuring in India, Bull. 56, Agr. Research Institute, Pusa, 1916.

(2) King, F.H.: Farmers of Forty Centuries or Permanent Agriculture in China, Korea and Japan, Madison, Wisconsin, 1911.

stand with the result that the soil is well aerated. The heavy rain therefore does not affect the wheat crop as far as drainage is concerned. Drainage is further favoured by the fact that the soil of this tract is not heavy due to its gravelly nature. The Bhabar tract is the characteristic feature of this region which has already been described in the last chapter. The Tarai portion of this tract is specially suitable for rice, but the Bhabar and Doon is pre-eminently suited to the cultivation of wheat. Cattle grazing is another very important industry of the upland region, the farmyard manure produced by the cattle being utilized for the crop production. The richness of the hills in minerals results in a highly fertile silt being carried down by the torrents. Winter rainfall is sufficient to bring the crop to maturity provided mulch formation and other factors governing conservation of soil-water are practised. The government and private canals also help in irrigating the wheat in the winter months. Wheat requires irrigation twice at least in the hilly region though in the alluvial plains very good results have been obtained with only one irrigation. In Naini-Tal the percentage of wheat to the total cropped land is more than 27 whereas in Dehra-Dun it rises as high as 39.1 per cent due to the open nature of the sub-soil in the doons of the last named district.

The Tarai includes the districts of Gorakhpur, Basti,

he may fully realise the possibilities of improvement and the part it could play towards agricultural prosperity, Adversities of weather are greatly against him; he has to fight hot dry winds in May and June, occasional floods in July and August, frosty nights in December and January, strong winds in March and hailstorms in April. His life is a great struggle for existence. His capital is limited and he has to borrow money from the village money-lender who too often is a dishonest unscrupulous type of fellow who charges even as much as $37\frac{1}{2}$ per cent interest. Once he gets into the clutches of this money-lender he seldom can free himself from his vicious ways. Thanks to the recent intervention of the state, interest of more than 12 per cent cannot be charged on any account. This law was enacted in the teeth of opposition from the capitalists, ~~but~~ ^{as} in 1936/the main need was to give relief to the agriculturists.

The fact that the Indian cultivator does not use labour saving devices which facilitate his work has its own justification. Tractor cultivation is not possible in the light alluvium because the soils being light enough, any deeper cultivation will increase the pore space and the result will be soil deterioration instead of soil improvement. Heavy soils will not be able to bear the weight of tractors which are too large for Indian conditions. Fragmentation of holding is another drawback against the use of

tractors.. Deeper cultivation will bury the weeds instead of bringing them up. The fine tilth which the farmer wants for the conservation of every drop of rain water is only possible with his native plough. Besides, the load on the bullocks may be too great in case of deeper ploughs.

Bigger clods will be formed after a deep cultivation which, after drying, will be difficult to level up. Deep cultivation may bring up sterile sand or clay to the surface and hence deteriorate the soil. Considering all these facts, we cannot condemn the Indian cultivator for not giving a deep ploughing to his soils, The Punjab ploughs are too heavy for the small and half-starved cattle of the eastern districts. Weston ploughs are the only ones which can be safely recommended for the Province as a whole. The writer when a student in the Government Agricultural College, Cawnpore, vividly remembers the difficulties he had to encounter with a Punjab plough because of the heavy strain on the cattle. Light harrows for intercultural operations can be safely utilized and light harvestors are also in demand. Improvement in the economy of labour can only be effected by such light agricultural implements as the above. A comparison of the agricultural conditions of the East and West is not possible, firstly on the basis of capital, secondly on the conditions of soil, thirdly on the character of rainfall and finally on the standard of living.

An enormous rise in the density of population is causing a heavy pressure on the land. The natural tendency therefore is that the lands at the margin of profitable cultivation are coming under the plough. Poor return is the inevitable result, in spite of all these handicaps, the Indian cultivator adjusts his soil so nicely by rotation, sowing of mixtures, fallowing of land and so on, that he never brings his soils to the point of exhaustion. Wherever he can get hold of ready manure he starts intensive farming. Extension of the sugarcane area and rise in multiple cropped land clearly point towards an intensive system of cultivation due to a rise in population.

It is often said that the fertility of the Indian soils are deteriorating. As an answer to this question Dr. Voelcker stated that they are becoming exhausted (1) but his view has been shattered by Prof. Wallace of Edinburgh (2). Under such conflicting opinions it is rather presumptuous for the writer to give his own opinion, but from the foregoing discussions on the nitrogen problem it is rather difficult to hold the former view. In absence of any detailed statistics to support Dr. Voelcker's views we can only say that the probability is that the Indian soils are not being

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- Report on the*
- (1) Voelcker: *Improvements of* Indian Agriculture, 1897.
- (2) Leather; J.W.: A Note on the Composition of Indian Soils.
- *Agricultural Ledger 1898 - No 2.*

exhausted. Besides the soils are being replenished by a supply in so many different forms that it becomes rather unscientific to hold his view.

Co-operative Societies:- Improvements in this line have been very unsatisfactory. Though the utility of such societies has been so greatly studied in other countries for the uplift of the rural masses, India is far behind. It takes a long time to do some constructive work as the obstructions in the way are too numerous. A lesson from Denmark will be of great benefit to an agricultural country like India. Co-operative credit societies to supply capital to the cultivators for any improvement that they wish to inaugurate in their lands is a necessity of the first magnitude to the Indian cultivators. Co-operative marketing societies for the purpose of joint marketing is the next most important need of the Province. Co-operative breeding societies where the bulls would be available to the cultivators at a nominal price would go a long way towards cattle improvement in the Province. Co-operative tube well societies will also be of tremendous help to agricultural improvement. In short, where large sums of money are needed for the improvement of agriculture, the cultivator looks to the state for help and the co-operative societies in such cases can render great service to the suffering humanity of India and can save them from misery. For the establishment

of such societies India needs her educated young men with unselfish motives. Any directing of energy by her young men towards this side will surely bring the day of happiness in the history of her agriculture.

Improved Seed Stores:- The Province is supplied with a network of seed stores stocking improved seed, The improved types of seed are constantly in demand by the cultivating masses. It goes without saying that any improvement in this respect will be highly appreciated by the farmers. Such stores at every big village will be a step towards agricultural improvement. Though this Province is fortunate in having widespread seed stores their number is insufficient to cope with the needs of the farmers. Here again co-operative societies can do much more than the local government has done so far. The very demand for seed stores is a healthy sign as it shows a system of co-operation and faith between the farming classes and the research workers of the Department of Agriculture who have issued the improved varieties of seeds.

Another improvement in seed distribution can be achieved if air-tight seed bins can be provided to the cultivators. In the words of Howard "if a supply of cheap, galvanised, seed bins with air-tight, dished-in lids could be supplied with the seeds, a further step in seed-distribution could at once be reached" (1).

(1) Howard, A.: Development of Indian Agriculture, 1927, p. 80.

Grading of Produce:- An examination of the conditions of the Indian markets reveals that all sorts of mixtures are being bought and sold. The worst and the best qualities are mixed up in such a way that the buyer, if he is pessimistic about the quality, offers a sum which is much below the actual price of the produce and the cultivator who produced them with the sweat of his brow gets a lower price than he deserves. If the buyer is optimistic about the quality, which he seldom is, he loses his good money. It becomes utterly impossible to fix a price for the village products under these conditions. As all wheats or cottons are sold at the same price, the grower of the good varieties is always the loser. It is time that such a practice should be stopped and the produce graded before they are sent to the market for disposal. Here again the co-operative grading societies are the only source which can come to the rescue of the village community. Countries like Canada have saved large sums of money by the simple process of grading of wheat. The United States with tobacco, and Denmark and New Zealand with butter, have done likewise. The small grower who is often the loser under the existing conditions can get a fair price when his produce has been graded, and it is he who can ill-afford to lose even a penny on the bargain.

Cottage Industries:- With a rise in population and

remote chances of the outlet of the extra population in major industries, the only solution is the development of agriculture and the associated cottage industries. It may be remarked that India is self-sufficient for her needs and the only solution therefore should be industrialization. Like Russia she can industrialize to at least the extent of her own needs. Unfortunately we are not discussing here the case of India as a whole, but only the problems of the masses of the U.P. In the absence of coal and iron, U.P. can never be an industrial centre and therefore its population has to confine its energy to agriculture and its associated cottage industries such as silk-worm rearing, bee-keeping, lac cultivation, rope making and spinning, etc.

An Indian cultivator after he returns from the field, goes to the Chopal (village headman's outside courtyard) and his talks are confined to speculation of weather and his crops, fluctuations of the market or the litigation between himself and the Zamindar. With a reasonable amount of propaganda he will understand the value of the cottage industries and will strongly welcome a subsidiary income from this source. He and his family can work on these cottage industries in their spare time and especially the off-season. Though since Gandhi's movement spinning has become a partial cottage industry in nearly every household, a wider outlet for the landless labour towards cottage industries is what the

Province needs to-day. Improvement of the cottage industries has not been taken seriously by the social workers or by the state and it is high time that a serious thought was given to this branch of agricultural prosperity.

Fodder Growing and Cattle Improvement:- There is certainly a great scope for improvement in this direction. It has been dealt with in the chapter on Cattle. It can be summed up in the following sentences:-

1. Since the establishing of regular pedigrees is not possible at present, grading is the only possible means of effecting systematic breeding. The present viceroy, Lord Linlithgow, being interested in this branch, has given a great impetus to improvement on the above lines.
2. Breeding dual-purpose cattle is necessary as milk animals are as important as draft animals.
3. Controlled breeding under the care of the cattle breeding department is needed, and skilled breeders should be employed for the purpose.
4. Local breeding to suit the conditions is more important than importing better cattle from other parts, as that involves risk in acclimatization.
5. Dedicated bulls should be castrated as far as possible.
6. The selection of the sire is more important than the selection of cows.
7. Controlled grazing is to be practiced as far as possible.

8. Grazing lands should not be brought under the plough as that will minimise the already small grazing areas.

9. The growth of fodder should be encouraged.

Communications:- From the beginning of this century there has been a tendency towards improvement in communications. As has been recorded before in a previous chapter, the mileage of roads and railways has been doubled within this century. This is undoubtedly a healthy sign of agricultural prosperity but a great deal has yet to be done. The improvement in this direction is a question of funds and it is certainly gratifying to be able to record that a due consideration is being paid to this. The Province still suffers from the need of roads, as can be very well illustrated by the fact that as soon as a road is metalled or a new road is built, the traffic increases tremendously. Not only will the building of new roads or repairing of the old ones solve the problem, but a good deal can be done to reduce the cost of maintenance.

Summing up, it can be said that the line of improvement suggested ^{above} ~~by the committee~~ has been partly taken up and a part yet remains to be worked. The most important point in the improvement of agriculture is funds and as soon as these are available, it is hoped that the channels of improvement will be tapped. Different commissions on agriculture from time to time have pointed out the needs, and these have been

carried out as far as funds have allowed. It can therefore be affirmed that the Province has always taken a right lead towards agricultural improvement and has been successful in fulfilling its obligations to the 50,000,000 of its population.

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